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SOCIAL HISTORY AND AGRICULTURAL PRODUCTIVITY: THE PARIS BASIN, 1450-1800

Philip T. Hoffman

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## **Abstract**

This paper uses a sample of leases and a new method to examine total factor productivity in the Paris Basin during the years 1450–1789. After defending the methodology, the paper analyzes the results from the sample, which should dispel the myth of agricultural stagnation in Old-Regime France, at least in the Paris Basin.



Historians should remain eternally grateful to Claude Sarasin.<sup>1</sup> Like all the canons at the Cathedral of Notre Dame in early eighteenth-century Paris, he could have led a life of uncontaminated leisure, with few obligations besides perfunctory attendance at daily offices. Although he did hold the post of archivist at the cathedral, the position was largely ceremonial, and no one actually expected him to sift through Notre Dame's voluminous papers. That messy task could be left to paid assistants, while Sarasin simply collected his pay.

Yet Sarasin did not do what was expected of him. Obsessed with cracking vellum and bound leather registers, he began to compile a detailed index of Notre Dame's capitular acts, where, among other decisions, the leases of Notre Dame's extensive property holdings were recorded. He spent years on the project, and when he ceased work in 1743, his index comprised more than one hundred manuscript volumes in a squat Latin hand. Thirty-three alone were devoted to Notre Dame's properties--most of them farms in the Paris Basin--and in them one finds details of leases from the late Middle Ages up to the middle of the eighteenth century. Today his index, along with the rest of Notre Dame's papers, is stored in Paris at the Archives Nationales.

The virtue of Sarasin's index is that it can be combined with other, equally valuable documents in Notre Dame's archives, such as records of land surveys and farm management, accounts of property seized at the beginning of the French Revolution, and, most important of all, a voluminous and well-organized collection of original leases. When linked together, the various records permit one to follow individual farms and pieces of agricultural land, with matching series of leases and property descriptions, from the fifteenth century to 1789. The records thus allow us to track a large number of identical properties through time, an advantage that has eluded most other historians working on leases. Indeed, most other researchers have worked with random samples of different properties, and the heterogeneity of the properties has clouded their conclusions.<sup>2</sup>

What follows is an analysis of 808 leases gathered from Sarasin's index and from the archives of Notre Dame.<sup>3</sup> The leases form 39 series, each one concerning a separate property in one of 25 different villages scattered throughout the Paris basin (Figure 1). The properties in question lay on

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<sup>1</sup> The author wishes to express his gratitude to participants at seminars at UC Davis, the University of Illinois, and Washington University; and to members of the audience at the Second World Congress of Cliometrics and at the 1989 meetings of the Society for French Historical Studies and the All-UC Economic History Group. Robert Allen, Shawn Kantor, Jean-Michel Chevet, George Grantham, Peter Lindert, Ted Margadant, Larry Neal, Kate Norberg, John Nye, Gilles Postel-Vinay, Angela Redish, Jean-Laurent Rosenthal, Ken Sokoloff, and David Weir deserve special thanks for their comments and criticisms.

<sup>2</sup> Léon Le Grand, "Claude Sarasin, intendant des archives du chapitre de Notre-Dame de Paris et sa collection d'extraits des registres capitulaires de Notre-Dame," La bibliographie moderne 4(1900): 333-71; Jean-Paul Desaive, "A la recherche d'un indicateur de la conjoncture: Baux de Notre-Dame de Paris et de l'abbaye de Montmartre," in Les fluctuations du produit de la dîme: Conjoncture décimale et domaniale de la fin du Moyen Age au XVIIIe siècle, ed. Joseph Goy and Emmanuel Le Roy Ladurie (Paris, 1972), pp. 44-57. Desaive was the first to use Sarasin's index as a source of leases, but he tried to read from the leases an indication of farm grain output. My innovation has been to combine Sarasin with the original leases and property descriptions in the Notre Dame archives and to analyze the resultant series of leases in a very different way, using both economic theory and multivariate statistics. For other work with leases in the Paris region, see Jean Jacquart, La crise rurale en Ile-de-France, 1550-1670 (Paris, 1974), pp. 614-18, 637-39, 699, 772; idem, "La rente foncière, indice conjoncturel?," Revue historique 514(1975): 355-76; and Béatrice Veyrassat-Herren and Emmanuel Le Roy Ladurie, "La rente foncière autour de Paris au XVII<sup>e</sup> siècle," Annales E.S.C. 23(1968): 541-55.

<sup>3</sup> Sarasin's index is in the Archives Nationales [henceforth AN] in Paris, LL 80-82, 233-352/354. The leases come from the index volumes LL 319-350/351 and from the originals in AN S123-462. AN S123-462 also contains property descriptions, land management records, and declarations made when Notre Dame's property was seized in 1790, all of which I relied upon.

average a little less than 40 kilometers from Paris, with the closest only 5 kilometers from the city center and the furthest 96 kilometers away. Most were rented along with only minor rights to collect the local tithe or local seigniorial dues, and none changed significantly in size, for if the size did change appreciably, I began another series of leases for what I considered a different holding.<sup>4</sup> As a whole the properties ranged from a minuscule plot measuring only 0.26 hectare (roughly two-thirds of an acre) to an enormous farm of 278 hectares, or roughly 700 acres, and they averaged 67 hectares. They were devoted almost exclusively to grain production: only 1.4 percent of the land was sown with vines and only 4.8 percent was natural meadow.<sup>5</sup> The result was not a random sample--few of the properties stood east of Paris--but it does not seem terribly unrepresentative.

If properly analyzed, the leases in the sample shed considerable light on the productivity of agriculture in Old-Regime France. When combined with product prices and the costs of the factors of production, they give us a measure of productivity, and not merely the partial productivities of land or of labor, but total factor productivity, the ratio that takes into account all the factors of production used in farming. Leases have previously been employed in this way to study the productivity of English agriculture, and although their use may at first seem a picaresque adventure in pseudo-statistics, they ultimately yield evidence firmer than the shaky figures we have for French crop yields and output per worker. They paint a somewhat startling picture of an agriculture capable of considerable Smithian growth, at least in the charmed environs of Paris, and they help us discern, more precisely than in the past, the causes of growth and stagnation under the Old Regime.

### 1. The Problem of Agricultural Productivity in France

The consensus of course is that French agriculture stagnated under the Old Regime and well into the nineteenth century. Behind this judgement lies a long-standing comparison with England, dating back to the late eighteenth century and the English agronomist Arthur Young. While English farmers worked large, capital-intensive farms with the latest techniques, Young noted disparagingly, French peasants tilled minuscule scraps of land with meager capital and an outmoded technology. Young even denounced agricultural practices in the most advanced regions of France, such as the Paris Basin, where large farms and market production were hardly uncommon. Historians today repeat the same refrain, making France the foil against which England shines. In early modern France, intones Pierre Goubert, agriculture "hardly progressed," whereas elsewhere, and particularly in England, it "experienced profound and rapid change." Robert Brenner condemns French agriculture in similar tones and traces the problem back to the peasant economy. Producing for self sufficiency and nothing more, French peasants operated tiny farms and blocked innovation. Even in the highly commercialized environs of Paris, contends Brenner, they throttled the sort of agricultural growth common in England.<sup>6</sup>

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<sup>4</sup> For area changes and for the issue of tithe rights and seigniorial dues, see the appendix, which also discusses how I treated rent arrears, in-kind payments, charges (additional payments made by tenants), pots-de-vin (entry fines), contre-lettres (secret letters modifying the original lease), repairs, farm buildings, and a host of other problems afflicting early modern leases. Jacquart, "La rente foncière," contains a brief discussion of these problems.

<sup>5</sup> All averages here are calculated counting each lease separately; if we were instead to weight each property equally, the averages would not change appreciably.

<sup>6</sup> Arthur Young, Voyages en France en 1787, 1788 et 1789, ed. and tr. by Henri Sée, 3 vols. (Paris, 1931), 1:89-91; 2:615, 727, 732-58, 784-91; 3:1224, 1330; Pierre Goubert, "Le paysan et la terre: seigneurie, tenure, exploitation," Histoire économique et sociale de la France, ed. F. Braudel and E. Labrousse, vol. 2: Des derniers temps de l'âge seigneurial aux préludes de l'âge industriel (1660-1789) (Paris, 1970), pp. 119-160; Robert Brenner, "The Agrarian Roots of European Capitalism," The Brenner Debate: Agrarian Class Structure and Economic Development in Pre-Industrial Europe, ed. T. H. Aston and C. H. E. Philpin (Cambridge, 1985), pp. 302-08.

Quantitative evidence seems to bear out the harsh judgement. In 1835-44, O'Brien and Keyder estimate, French agricultural workers produced only 58 percent of the amount their English counterparts did, and Anthony Wrigley has argued that the breach between French and English labor productivity reaches back to the seventeenth century. French land seemed less productive as well. While fields in much of England yielded better than 20 hectoliters of wheat per hectare in the middle of the nineteenth century, France could match this performance only in its minuscule northern tip. According to Michel Morineau, French yields had not increased during the preceding century, and in some regions they had not budged between the end of the Middle Ages and 1840.<sup>7</sup>

The problem, however, is that the evidence behind the indictment of French agriculture is far from convincing. In the first place, much of the contrast between French and English agriculture merely reflected natural endowments and comparative advantage, not any failing on the part of the French. It reflected poorer soil and other natural conditions, which handicapped the south of France in particular. And it reflected different crop mixes, the French for example having a comparative advantage in crops such as grapes, which demanded considerable labor and drew manure away from grain.<sup>8</sup>

Furthermore, the very evidence about labor productivity and yields in France is far from reliable. One can, for example, raise serious doubts about the various labor productivity figures because they involve determining the size of the agricultural labor force, a calculation that, even when done with nineteenth-century census records, is fraught with difficulty. How does one calculate what fraction of the rural population worked in farming when many denizens of the countryside toiled in cottage industry?<sup>9</sup>

Similar doubts cast a shadow on Morineau's yield figures. Critics have questioned his arithmetic and stressed that his conclusions rest upon a handful of examples. Whether the critics are correct or not, it is in any case clear that comparing grain yields over time is a treacherous undertaking. Grain output per acre varied drastically from one end of a farm to another and from village to village, casting doubt on any comparison between, say, a sixteenth-century yield taken from a probate description of a particular field and a nineteenth-century yield calculated from a census average for the surrounding arrondissement. Temporal variations make comparisons of yields from century to century equally difficult. A bad hailstorm alone could wipe out all the wheat in a

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<sup>7</sup> Patrick O'Brien and Caglar Keyder, "Les voies de passage vers la société industrielle en Grande-Bretagne et en France (1780-1914)," Annales E.S.C. 34(1979): 1284-303; Anthony Wrigley, "Urban Growth and Agricultural Change: England and the Continent in the Early Modern Period," Journal of Interdisciplinary History 15(1985): 683-728; Jack Goldstone, "Regional Ecology and Agrarian Development in England and France," Politics and Society 16(1988): 287-334; Michel Morineau, Les faux-semblants d'un démarrage économique: Agriculture et démographie en France au XVIIIe siècle, Cahier des Annales, no. 30 (Paris, 1971). Recent work has questioned this view; in addition to Goldstone, see Robert Allen, "On the Road Again with Arthur Young: English, Irish, and French Agriculture during the Industrial Revolution," Journal of Economic History 48(1988): 93-116; Jean-Michel Chevet, "Le Marquisat d'Ormesson, 1700-1840: Essai d'analyse économique," 2 vols. (Doctoral Dissertation, Ecole des Hautes Etudes en Sciences Sociales, [1983]); George Grantham, "Agricultural Supply during the Industrial Revolution: French Evidence and European Implications," Journal of Economic History 49(1989): 43-72; idem, "The Growth of Labour Productivity in the 'Cinq Grosses Fermes' of France, 1750-1933," in Bruce Campbell and Mark Overton, eds., Productivity Change and Agricultural Development (Manchester, forthcoming); Gilles Postel-Vinay, "A la recherche de la révolution économique dans les campagnes (1789-1815)," Revue économique 6(1989): 1015-46; and forthcoming work by Chevet, Grantham, Postel-Vinay, and Jean-Marc Moriceau.

<sup>8</sup> Grantham, "Agricultural Supply," pp. 43-72.

<sup>9</sup> Postel-Vinay, "A la recherche de la révolution économique," pp. 1029-1033; J. P. Bompard, Thierry Magnac, and Gilles Postel-Vinay, "Emploi, mobilité et chômage en France au XIXe siècle: Migrations saisonnières entre industrie et agriculture," Annales E.S.C. 45(1990): 55-76.

village. Worse, even seemingly reliable averages can be deceiving. If wheat supplants crops of lesser value (such as rye) on poorer soil, then average yields for wheat can stagnate or decline, even though the value of output per acre and physical yields themselves (on soil of a given quality) are rising.<sup>10</sup>

If extending yield figures back seems too difficult or perhaps even misleading, one might seek refuge, as numerous French historians have, in measurements of total output derived from records of the tithe. The problem is that rights to the tithe were divided among numerous institutions and individuals, and the records of the tithe may thus say more about competing property rights than about actual agricultural output. Indeed, numerous examples demonstrate that the sort of tithe figures historians typically rely upon are likely to omit output from innovations such as artificial meadows and new crops such as turnips. A flat graph of tithe figures could thus easily mask technical change.<sup>11</sup>

It is difficult then to derive reliable estimates of the agricultural labor force and to extend yield and output figures back into the past. And none of these figures give us total factor productivity: even when reliable they furnish only partial productivities and usually only for a single crop, such as wheat. What of agricultural capital and the other factors of production? And what of the farm products that even the tithe figures skip, such as meat? What we need of course is a new source of information, preferably one that lets us measure not just one output or the productivity of one factor, but total factor productivity.

## 2. Using leases and prices to measure productivity

Surprisingly, such a source exists. It survives in the leases abundantly recorded under the Old Regime and preserved in notarial archives, family papers, and ecclesiastical records. When combined with prices and wages, the rental figures in the leases yield a measure of total factor productivity that, while itself open to objections, seems much more reliable than the dubious physical measures of output per worker or even output per acre.

Using prices and rental figures to measure total factor productivity (TFP) was first suggested by Donald McCloskey, in his analysis of English enclosures. More recently, Robert Allen has employed them to examine the productivity of enclosures and of English agriculture in general in the early modern period.<sup>12</sup> What McCloskey and Allen rely upon is the fact that TFP can be calculated with prices and rents in place of the actual physical measurements of the products and factors of production. The definition of TFP here is a standard one. It gauges the effectiveness of farm production and is defined--roughly speaking--as the average product of all the inputs to farming. Its rate of change equals the speed at which farm production is growing less the rate at which use of

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<sup>10</sup> For criticisms of Morineau, see Emmanuel Le Roy Ladurie, The French Peasantry 1450-1660, tr. Alan Sheridan (Berkeley, 1987), p. 430. For difficulties with comparisons of yields, see Jean Meuvret, Le problème des subsistances à l'époque Louis XIV, 3 vols. (Paris, 1976-88), vol. 1, pt. 1 (Texte): 207-211.

<sup>11</sup> In 1603, for example, the canons of the cathedral of Notre Dame went to court on behalf of their tithe collector in the village of Louvres because he was unable to collect the tithe on land recently put into cultivation and sown with turnips. In 1713-16 they lost the tithe on new artificial meadows in the village of Dampmart to the local curé. In these examples, the sort of tithe records historians use--records of large ecclesiastical institutions such as Notre Dame--might even show a decline in the tithe at a time of agricultural improvements. See AN LL 327-28, fols. 12-17; LL 331, fols. 210-50. For examples of the use of the tithe, see Goy and Ladurie, Les fluctuations du produit de la dîme, and idem, Prestations paysannes, dîmes, rente foncière et mouvement de la production agricole à l'époque préindustrielle, 2 vols. (Paris, 1982).

<sup>12</sup> Donald McCloskey, "The Economics of Enclosure: A Market Analysis," in European Peasants and Their Markets, ed. William N. Parker and Eric L. Jones (Princeton, 1975), pp. 123-76; Robert Allen, "The Efficiency and Distributional Consequences of Eighteenth-Century Enclosures," Economic Journal 92(1982): 937-53.



the factors of production is increasing, with each product weighted by its share in total revenue and each factor by its share in total cost. If we also assume, as Allen does, that the product and factor shares remain constant over time (an assumption that turns out to be very reasonable for early modern agriculture), then an index for TFP itself can be fashioned from a suitable power of the ratio  $(r + t)/I$ , where  $r$  is per-acre rent,  $t$  is per-acre taxes, and  $I$  is a geometric index of agricultural product prices divided by factor prices for the factors of production other than land.<sup>13</sup>

We can thus measure TFP either as a weighted ratio of output quantities produced divided by factor quantities utilized, or, equivalently, as a weighted ratio of factor prices divided by product prices. The point is that more efficient techniques and organization not only increase physical outputs for a given level of inputs: they also depress product prices relative to factor prices and ultimately show up in the form of higher profits and rents, once we correct for the variation in prices and wages via the price index  $I$ . If a clever farmer discovers how to increase his productivity--perhaps he manages to squeeze more wheat from the same plot of land, the same amount of capital, and the same amount of toil--then he will reap higher profits as well, profits that will eventually fund higher rent payments to his landlord. If others imitate him, the price of wheat may fall, but TFP, which is a weighted ratio of factor prices divided by product prices, will still increase. On the other hand, a mere shift in rents, wages, and prices in response to population change or price inflation will not affect TFP. If the population increases, for example, rents may rise relative to agricultural prices, while wages fall. Yet the index of TFP, if it is properly calculated, will remain the same.<sup>14</sup>

The whole method of calculating TFP, of course, is open to a host of objections. Some are technical and are discussed in the appendix. More important, however, and far more interesting, are the assumptions underlying the whole exercise, which may evoke howls of execration from social historians: that the agricultural technology is known, that agricultural markets existed, and that the land rental market was competitive. They obviously deserve detailed scrutiny.

The first assumption is that we be able to trace at least the rough features of the agricultural technology. In other words, we must know how much labor a typical farmer in the Paris Basin employed and how much capital too, be it seed, livestock, or implements. We must know what he produced as well. Fortunately, the requisite information can be gleaned from contemporary agricultural treatises and from records of actual farms, and although one might worry about variations from farm to farm and over time, they are not severe enough to disturb our calculations of TFP.<sup>15</sup>

The calculations also assume the existence of rudimentary markets in which the factors of production can be purchased and farm products sold. We must be able to measure prices in these markets, and the land rental market must be close to competitive. Not all of a farmer's dealings need have passed through the factor and product markets, merely a portion. As long as he had some involvement in the markets, though, it would be fair to say that the shadow prices he faced equalled market prices, once we allowed for the costs of transportation and of market preparation. Such an equivalence of market and shadow prices is all that is needed--not full market participation.

Here, obviously, we may raise historians' hackles, for Old-Regime farmers are usually considered self sufficient peasants, who were thoroughly isolated from markets. The evidence,

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<sup>13</sup> For the definition of TFP, see Robert G. Chambers, Applied Production Analysis: A Dual Approach (Cambridge, 1988), pp. 238-88. Although some readers might balk at the constant shares assumption, it turns out to be a reasonable one for early modern agriculture. Furthermore, even shares did vary, our results would not be disturbed. For a discussion, see the appendix, which also derives the formulas for TFP and for its rate of change and explains the index  $I$ .

<sup>14</sup> For detailed discussion, see the appendix.

<sup>15</sup> For details, see the appendix, which examines the other assumptions needed to calculate TFP as well. The evidence about the technology is used to estimate factor shares, which are then employed as weights for the prices in the calculation of TFP. Since the prices are all highly correlated and since it is only trends in the prices that matter, errors in the factor shares hardly disturb the estimates of TFP.

though, suggests that self sufficiency itself was largely a myth. This was certainly the case in the Paris Basin. Except in the rare parishes blessed with extensive commons or with unusually fertile soil, self sufficiency required ownership of about 10 hectares, and almost no peasants owned this much land around Paris. One did encounter independent vignerons, but they tilled vines for sale in the market. Nearly all the other peasants in the Paris Basin either worked on the side as farm laborers or rented land in a tight land market; by no stretch of the imagination were they self sufficient.<sup>16</sup>

To survive, then, many peasants were obliged to sell their own labor. They did of course spend time cultivating their own gardens and tiny plots, but they also worked for wages and were thus at least partially engaged in the labor market. Such an assertion may of course shock those who conceive of wage labor as an invention of modern capitalism, but the fact is that labor markets of a sort operated as early as the fifteenth century, if not before. If one examines tax rolls from the late sixteenth and early seventeenth centuries, for instance, one discovers an army of agricultural laborers, who neither rented nor owned enough land to feed themselves. Diaries and account books let us glimpse them as they passed through farms. From the accounts of the Cairon family in late fifteenth-century Normandy, for instance, we see the family's engaging half a dozen ploughmen and servants each year; the rapid turnover and the fact that many came from some distance are hard to understand without the intervention of a labor market. In the sixteenth century we know that unskilled workers from Paris helped take in the harvest in the surrounding countryside, while building laborers covered enormous differences in the search for jobs. By the eighteenth century, and probably long before, workers descended from as far as the Limousin to cut wheat in the Paris Basin.<sup>17</sup>

Most migrants of course travelled much shorter distances--they shuttled about in their pays, moving from neighboring village to neighboring villages--but their brief circuit sufficed to create a rudimentary labor market. One might still doubt, though, that wages could be measured, for pay

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<sup>16</sup> Chevet, 1:173-74, 383; 2: 406-23, 440, argues that more than 10 hectares is needed for self sufficiency and finds that in 1717 only 12 percent of the peasants in the Brie (the region to the southwest of Paris) owned or even rented farms over 10 hectares. He found similar or lower percentages in other eighteenth-century documents. Pierre Goubert, Beauvais et le Beauvaisis de 1600 à 1730, 2 vols. (Paris, 1960; reprint ed., 1982), 1:182, also argues that 10 hectares was necessary for self sufficiency; he found that ownership of 10 hectares was rarely attained in the Beauvaisis, to the north of Paris. George Lefebvre, Les paysans du Nord pendant la Révolution française (Paris, 1924; reprint ed., Bari, 1959), pp. 286-87, argued that 5 hectares was enough for self sufficiency on the fertile soil of Flanders, but 10 hectares was needed in Cambresis and Hainaut, near the Belgian border. In the Hurepoix south of Paris, Jacquart, La crise rurale, pp. 104, 119, 133-34, 352-57, 724, 749-51, found that possession of the plows and horses needed for independence was rare on properties under 10 hectares and that peasant ownership of 10 hectares was extremely unusual in the sixteenth and seventeenth century. Of 2010 peasant tenures he examined in the mid sixteenth century, for example, only 20 exceeded 10 hectares.

<sup>17</sup> Archives départementales [henceforth AD] du Calvados (Caen), F 1652; James B. Collins, Fiscal Limits of Absolutism: Direct Taxation in Early Seventeenth-Century France (Berkeley, 1988), pp. 183-90, 210-212; idem, "Geographic and Social Mobility in Early Modern France," paper delivered at the Sixteenth Annual Meeting of the Western Society for French History, Los Angeles, November 4, 1988; Micheline Baulant, "Le salaire des ouvriers du bâtiment à Paris de 1400 à 1726," Annales E.S.C. 26(1971):463-83; idem, "Prix et salaires à Paris au XVIIe siècle: Sources et résultats," Annales E.S.C. 31(1976): 954-95; Alexandre-Henri Tessier et al., Encyclopédie méthodique ou par ordre de matières: Agriculture, 7 vols. (Paris, 1787-1821), vol. 1: sv "affanures," and "avoine"; vol. 3: sv "faucher" and "faucilleux." The evidence for mobility runs counter the impression of great immobility given by demographers. The reason is that marriage records and endogamy statistics tend to exaggerate immobility since people came home to marry. Furthermore, mobility was undoubtedly tied to the life cycle and much of the migrating took place within a very restricted area. A young women might work as a farm servant in a nearby village and then return to her home to marry and settle down. Such mobility would never appear in the typical records used by demographers, even the early listes nominatives.

seemed to vary in a way totally incompatible with the operation of a perfect market with a unique wage. In sixteenth-century Paris, for example, one unskilled building worker might earn 7 sous a day, while another toiling at his side might be paid nearly three times as much. On the Cairon farm in Normandy, Mathieu Donesnal collected 75 sous and his keep in 1479 but 97 sous 6 deniers plus keep in 1480. Such enormous variation in wages, though, probably stemmed from differences in skills and strength--or at least this is what the foremost scholar of French wages has concluded. On the farm, higher wages for domestics who remained in service reflected skills and rewarded dependability and trustworthiness, qualities prized by early modern masters, who feared entrusting their crops and their herds to irresponsible servants. A higher wage for a Mathieu Donesnal who had served for a year or for a milkmaid whose family was known to the farmer was thus perfectly understandable. The farmer was relying upon previous service and reputation to select domestics who were skilled and dependable. His behavior differed little from that of a modern employer who might screen via credentials and experience. What we might therefore mistake as bizarre variations in wages was merely the smooth functioning of the labor market, which worked well enough to make keen distinctions among employees.<sup>18</sup>

There remains the practical problem of actually measuring wages. Ideally we would like the wage of farm labor, preferably unskilled. Farm wages, though, are difficult to appraise since domestics were often paid a considerable portion of their earnings in kind and since salaries varied from season to season and from task to task--one wage for a ploughman, another for a milkmaid, etc. The only alternative is to use urban wages for unskilled building workers. Modal wages would capture what the average unskilled building worker earned and allow us to overcome differences in strength and skill. One might object that urban and rural wages were different, but fifteenth and sixteenth-century evidence from the region around Paris suggests that wages for unskilled day laborers in the city differed little from those prevalent in the countryside, at least during the harvest when farmers hired day laborers. "In the sixteenth century, the wages of two laborers, one working in the fields and the other in the city, were identical," says Micheline Baulant, who has studied wages around Paris, and her data support her assertion. An unskilled urban helper earned 2.5 sous a day in 1500-05 and 10.4 sous a day in 1594-98; a hotteur in the grape harvest earned 2.5 sous in 1500-05 and 10 sous in 1594-95.<sup>19</sup>

Even if there were sometimes differences between wages in the city and wages in the countryside, the trend of pay for the unskilled was nearly everywhere the same, and it is this trend, and not absolute prices, that we need to establish changes in our index I and thereby in our index of TFP. For rural domestics and day laborers, for urban building helpers, and for a host of other unskilled city occupations, wages moved in parallel--or at least this is what the evidence from the

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<sup>18</sup> Baulant, "Le salaire des ouvriers," pp. 463-83; AD Calvados F 1652. There were also large seasonal differences in wages. Baulant argues that they resulted from the lengthening of the day in the summer, but they also reflected the effects of weather on building projects and the great demand for harvest labor. Cf. Bompard, et al, "Emploi, mobilité et chômage," and Yves Durand, "Recherches sur les salaires des maçons à Paris au XVIIIe siècle," Revue d'histoire économique et sociale 44(1966):468-80. One might fear that a servant who earned a premium because of his reliability and skill would hesitate to leave his employer and that the resultant lack of mobility would undermine the labor market. But such a servant made a reputation for himself among neighboring farmers, and like an experienced employee today he would fetch a higher salary if he left.

<sup>19</sup> Baulant, "Prix et salaires à Paris," pp. 980-86; similar fifteenth-century evidence can be found in Guy Fourquin, Les campagnes de la région parisienne à la fin du moyen âge (Paris, 1964), p. 496. For the near impossibility of dealing with agricultural wages, particularly in-kind payments, see Goubert, Beauvais, 1:139-40, 547-60; and Jean-Pierre Gutton, Domestiques et serviteurs dans la France de l'ancien régime (Paris, 1981), pp. 111-117.

Paris region suggests. It was true for the urban helper and the hotteur between 1500 and 1598; indeed, at this time, according to Micheline Baulant, it was true "whatever the task."<sup>20</sup>

Of course, one should not jump to the conclusion that a national labor market existed. Labor markets were regional, although the one about Paris was undoubtedly large enough to embrace the localities from which our leases were drawn. Nor should one overlook evidence that the labor market was perhaps segmented, with farmers in certain places and at certain times able to hire cheap labor at a cost that bore only a slight relationship to the wages paid in Paris. Family labor springs to mind, as does the use of unemployed agricultural laborers during the winter slack season. And perhaps rural pay in the eighteenth century no longer followed urban wages as closely as it had two centuries before.

There is some evidence for such segmentation, but given the current state of research it is as yet neither overwhelming nor convincing. In the first place, the segmentation, if it did exist, might be more a phenomenon of the nineteenth century than of the Old Regime. As for differences in remuneration from place to place, they are not large and they may in the end simply have reflected the heterogeneity of labor, the complexities of in-kind pay, and variations in the cost of living. Finally, it is difficult to argue for complete segmentation in face of the enormous mobility of labor in the Paris Basin under the Old Regime. Parisian workers, we know, helped take in the harvest. Domesticates quit the farm for the city, while paupers fleeing rural poverty did the same. And whole families moved in and out of the small towns about Paris, presumably in search of work. Given such mobility, particularly between Paris and the countryside, it seems unlikely that the regional labor market was partitioned into isolated and mutually exclusive compartments.<sup>21</sup>

We can also find the necessary markets and prices for agricultural capital--in particular livestock. Long distance markets for horses, cattle, and sheep reach far back into the past, and although prices series for livestock are skimpy and one has to be careful of differences between

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<sup>20</sup> Baulant, "Le salaire des ouvriers à Paris"; idem, "Prix et salaires à Paris," pp. 980-986.

<sup>21</sup> See Baulant, "Le salaire des ouvriers," p. 472; idem, "Prix et salaires," pp. 980-87; Marcel Lachiver, La population de Meulan du XVIIe au XIXe siècle (vers 1600-1870) (Paris, 1969), pp. 91-122; Jacques Béaud and Georges Bouchart, "Le dépôt des pauvres de Saint-Denis (1768-1792)," Annales de démographie historique, 1974, pp. 127-43; and forthcoming work by Gilles Postel-Vinay and J. M. Moriceau, who find that farm labor was more mobile in the eighteenth century than in the nineteenth century. The study by Postel-Vinay and Moriceau contains a table of cash payments to male domesticates on a single farm during the years 1731-51. If we compare these to the wages paid in Paris during the same years (unfortunately the Paris wage data is lacking for some of these years so that we must restrict ourselves to the 15 years when both sets of wages exist), we find that between 1731-37 and 1738-51 the Paris wages increased 5.8 percent, while the payments to the domesticates grew 7.1%. These figures are fairly close, but the domesticates also received food and other in kind payments. If we evaluate these as equivalent to 3 setiers of Paris wheat (evaluated using a moving average price), then compensation to the servants rose 10.1 percent, a figure considerably higher than the increase in Paris. Using local grain prices from Soissons leads to an even large increase of 12.5 percent, which suggests that rural compensation was perhaps deviating from Paris wages. Nonetheless, the Paris wage and the compensation paid the domesticates were still highly correlated ( $r = .671$  if we evaluate the in-kind payments using Paris prices), and what seems to be an increase in rural wages relative to Paris wages in the early eighteenth century could be little more than a statistical accident. If rural wages did increase relative to Paris wages throughout the eighteenth century, though, it would be hard to understand why harvest workers in the 1780s continued to earn the same pay as urban laborers, at least in some parts of the Paris Basin. For an example from the 1780s, see M. Bertrand-Lacabane, Brétigny-sur-Orge, Marolles-en-Hurepoix, Saint-Michel-sur-Orge (Versailles, 1886), pp. 241, and Durand, "Recherches sur les salaires."

breeds, it is possible to assemble the necessary series of prices trends--or at least gross averages for twenty-five year periods, which is all that is necessary for our price index I.<sup>22</sup>

Among agriculture outputs, it is grain that poses the most daunting problems. Grain had long been bought and sold, but the difficulties of transporting it severely restricted the scope of the market. Along with the difficulties of transportation, the high costs of storing grain and of preparing it for sale limited the short run supply, which (along with inelastic demand) made prices volatile and difficult to measure. And much grain seems to have escaped the market, reaching consumers in the form of payments in kind or self production. One might therefore assume that shadow prices for grain on the farm would bear no relationship to the market prices that would figure in our price index I.<sup>23</sup>

Yet the difficulties here are far from insurmountable. It would be absurd to maintain that the payments of grain in kind amounted to a second market, in which the shadow price of grain bore no relation to that of the open market. The canons of the Paris cathedral of Notre Dame received numerous payments in kind, but they evaluated the grain at the price current in the relevant market--in Paris if the grain was delivered in Paris, in a local market if they took possession in the countryside. And when it came time to sell grain from their stores, the canons watched the market to see what their grain would fetch.<sup>24</sup> The payments in kind, therefore, do not seem to have constituted a separate and unrelated market, all the more so since rights to the grain due in kind (tithe payments, for example) were often purchased for cash. The same logic casts doubt on the assumption that the shadow price of grain on the farm was unrelated to the market price. Most peasants had to buy grain to meet their needs, and among the tenants we shall study below there were many large scale farmers who frequently sold on the market.

The other problems with grain prices can also be resolved. Long-run averages can dampen price volatility, and although transportation costs drive a wedge between prices in distant markets, one does find that long run average price trends--all that is necessary for our price index I--tend to move together, as long as the markets are not too far apart. Around Paris, for instance, grain prices in local markets were lower and more volatile than in Paris in the sixteenth and seventeenth centuries, but price trends in the local markets up to 100 kilometers away tended to follow the trend of the Paris price, particularly if one examines averages that smooth out local crises. Such parallel movement should hardly be surprising, for there is considerable evidence that merchants and even large scale peasants carried out what amounted to intermarket arbitrage in the sixteenth, seventeenth, and eighteenth centuries. With individuals buying and selling once price gaps widened, it is no wonder that grain prices, though different in absolute terms, exhibited similar trends.<sup>25</sup>

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<sup>22</sup> For details see the appendix. There were regional variations in the price of livestock but they can usually be accounted for by differences in breeds, quality, age, and weight.

<sup>23</sup> Meuvret, Substances, vol. 3.

<sup>24</sup> From the fifteenth century to the eighteenth century, the cathedral of Notre Dame required that grain paid in kind for rents, tithes, and seigneurial dues fetch a price within a few percentage points of that prevailing in the Paris market. The only exceptions involved grain delivered to places other than Paris, and then Notre Dame used the price in local market. The aim of the policy obviously was to avoid being cheated, and the effect was to link in-kind payments to market prices. Among numerous examples, see AN S320, 27 November 1486; S324A, 25 June 1781, ("apprecier le...bled ...sur l'extrait des gros fruits du marché de Paris...à cinq sols près du meilleur froment qui y sera vendu"); S 359, 22 November 1496, ("à douze deniers Parisis chacun septier près du meilleur"); S380B. Notre-Dame's policy of keying grain sales to market prices had a similar effect. See Dupré de Saint Maur, Essai sur les monnoies ou reflexions sur le rapport entre l'argent et les denrées (Paris, 1746), p. 127 (1644).

<sup>25</sup> Steven L. Kaplan, Provisioning Paris: Merchants and Millers in the Grain and Flour Trade during the Eighteenth Century (Ithaca, 1984), pp. 206, 215-16; Jacquart, Crise rurale, pp. 764-66; Jacques Dupâquier, et al, Mercuriales du pays de France et du Vexin français (1640-1792), p. 233;

The last assumption we need is that untaxed profits from farming eventually went to landlords--or in other words, that the land rental market was competitive with no barriers to tenant entry. In the short run, it is clear, such was not always the case, for it might take a landlord time to renew a lease or even to realize that more could be squeezed out of a property. What concerns us, though, is the long run. One might suppose, for example, that powerful tenants might drive down rents and thereby retain some of the profits of farming even in the long run. George Lefebvre described such tenant farmers in the French department of the Nord, who, via a custom known as mauvais gré or droit de marché, barred landlords from evicting them or from raising their rent, and the Nord--near the Belgian border--was not the only region where tenants wielded such power. In the Paris Basin, for example, tenants surreptitiously rearranged fields, and dynasties of wealthy fermiers (large scale farmers) seemed to monopolize the tenancy of large farms.<sup>26</sup> Unlike the markets for labor, livestock, and agricultural products, which swarmed with hundreds of minuscule actors, the land rental market in any given village might involve only a small number of powerful fermiers and thus seem a far cry from competition.

Yet the market power of the wealthy fermiers has probably been exaggerated. As Lefebvre carefully pointed out, mauvais gré was unheard of in much of the Nord. Where it did occur it rested upon a highly unusual set of customs and property rights, and these customs and rights were in any case unknown throughout much of the Paris Basin, where Notre Dame's properties were situated.<sup>27</sup> Nor should one jump to conclusions simply because tenants exchanged parcels and rearranged fields, for landlords such as Notre Dame seemed unfazed by the practice. Notre Dame readily acknowledged that tenants might temporarily exchange plots rented from different landlords; it merely asked that its land be demarcated so that its property rights would not be obscured. And why would a landlord object to such exchanges? As long as he kept track of his property, he stood to gain from the increased efficiency.<sup>28</sup>

Furthermore, if overweening tenant had held down the rent, then one would expect to find frequent mention of it in manuals for landlords and in texts on agronomy. But one seeks it in vain, even though the writers in question devoted considerable attention to problems with tenants. Writing in the mid-sixteenth century, for example, Charles Estienne talks of cheating by tenants, of the damage they can do if they are not monitored, of the desirable qualities one should seek in a tenant, and of how a good tenant is to be rewarded, but he never suggests that tenants exercised any power over rents, nor even that it was difficult to evict a troublesome tenant. Writers in the seventeenth and eighteenth centuries repeat the same refrain. Far from complaining about the difficulties of

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Micheline Baulant and Jean Meuvret, Prix des céréales extraits de la mercuriale de Paris (1520-1698), 2 vols. (Paris, 1960-62), 1:12, 25. Baulant and Meuvret find evidence of arbitrage in the sixteenth and seventeenth centuries. They note that grain prices in Paris roughly paralleled those in Rozoy-en-Brie and were "de vrais décalques" of those in closer markets such as Corbeil. Dupâquier and Jacquart find similar parallels. As we shall discuss below, hinterland prices did seem to have risen relative to the Paris price between the seventeenth and the eighteenth century; for this, see Micheline Baulant, "Le prix des grains à Paris de 1431 à 1788," Annales E.S.C. 23(1968): 520-40.

<sup>26</sup> Lefebvre, Paysans du Nord, pp. 103-06, 274-82; Gilles Postel-Vinay, La rente foncière dans le capitalisme agricole (Paris, 1974), pp. 51-52; Jacquart, La crise rurale, p. 132; idem, "La rente foncière"; Jean Vinchon, Le livre de raison d'une famille picarde: Les Vinchon (1488-1947) (Doullens, 1948), pp. 36-37, 98-103; Hugues Neveux, Vie et déclin d'une structure économique: Les grains du Cambrésis (fin du XIVe-début du XVIIe siècle) (Paris, 1980), pp. 45-49.

<sup>27</sup> A droit de marché did exist in certain areas to the north of Paris: see Vinchon, Le livre de raison, pp. 36-37, 98-103; and Postel-Vinay, La rente foncière, pp. 44-49. But it seems to have been large unknown throughout the rest of the Basin and even to the north of Paris it was hardly universal; cf. Jacquart, "Rente foncière," p. 375.

<sup>28</sup> AN S 201 (1756), S 402 (23 April 1766), S 407 (25 August 1785).

dislodging powerful tenants, they stressed that it was in the landlord's financial interest to reward and to retain a good one. A dynasty of fermiers may thus have signified less a tenant's power than his talent, talent that ultimately profited the landlord.<sup>29</sup>

One bit of evidence that has been interpreted as a sign of tenant market power is the lower per-acre rent sometimes found on big farms and large plots of land, the argument being that tenants able to take on a large farm were powerful enough to force down the rental price.<sup>30</sup> The problem with such an argument is that most of the evidence for per-acre rents fails to take into account location and land quality; once they are factored in, the difference between large plots and small ones diminishes considerably. As we shall see below, doubling the size of a property cuts the per-acre rent by only 9 percent, hardly an enormous figure.

Moreover, there is a very different explanation for the lower per-acre rents that large plots sometimes fetched, an explanation that does not depend in the slightest on the market power of tenants. We should recall that renting out land, even for a fixed rent, involved risks for the landlord. His property might be overworked or ruined by neglect, or, worse yet, the tenant might fall behind paying the rent or not pay it at all. If early modern land management manuals and the experience of landlords like Notre Dame are to be believed, such risks were far from insignificant, even for small plots of land.<sup>31</sup> Because of them, a landlord might have to seek a judgement against a tenant or seize his assets. The problem, though, was that only the large scale fermiers had assets that a landlord could attach. They alone owned livestock and equipment, while the small scale tenants who leased the tiny parcels possessed no such collateral. The landlord could therefore allow big fermiers fall into arrears, knowing full well that their livestock and equipment served as collateral for their debts. With small scale tenants, however, the landlord had no such assurances, and his only recourse was to demand a risk premium in the form of higher rent payments. The higher rent was thus compensation for the risks posed by tenants without collateral.<sup>32</sup>

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<sup>29</sup> Charles Estienne, L'agriculture et la maison rustique (Paris, 1564), fols 8-9. To take but one example from the later literature, L'art d'augmenter son bien ou regles générales pour l'administration d'une terre (Amsterdam-Paris, 1784), pp. 171-75, suggests that tenants did not set rental prices, that it was not difficult to dislodge one or to attract a new one and that a landlord would do best in the long run if he retained a good tenant. Notre Dame seemed to have little trouble dislodging mediocre tenants in favor of better ones. In 1762, for example, they easily replaced their farmer in Dampmart with a one from another village and then boosted the rent considerably. Their agent, who sought out replacement tenants, told one prospective tenant not to approach the current tenant directly, but the agent's concern here seems to have been getting the current tenant to agree to an early end to the current lease. While discussing the pros and cons of coming to the farm with the prospective tenant, the agent never mentioned the sort of threats against new tenants that one might expect in the regions of mauvais gré. See AN S 242 (12 November 1753, 17 March 1761, and 3 February 1762).

<sup>30</sup> Postel-Vinay, La rente foncière, pp. 35-54; Grantham, "Agricultural Supply"; Gérard Béaur, Le marché foncier à la veille de la Révolution (Paris, 1984), pp. 263-64. The area Postel-Vinay studies is one where a droit de marché did exist and where fermiers did hold down rents.

<sup>31</sup> Estienne, fols. 8-9; L'art d'augmenter son bien, pp. 10-17, 171-75; Abbé François Rozier, Cours complet d'agriculture, 10 vols. (Paris, 1781-1800), vol 2, sv "bail"; AN LL337-38, fols. 96-101 (1748), fols. 236-37 (1747); LL 350-51, fols. 122-24 (1761-62); S 242(1754-62); S247 (1693); S 176 (1666-69).

<sup>32</sup> If there were also fixed costs associated with leasing land, then the only small plots of land that would be rented out would be ones of exceptional quality--yet another reason for higher per acre rents with small plots of land. Such fixed costs did exist in the early modern period--the cost of notarizing the lease, the cost of going to court in case of non payment of rent, the cost of inspecting the property--but it is doubtful that they could account for the 9 percent gap noted

Quantitative evidence of a different sort also casts doubt on the market power of tenants in the Paris basin. Although some tenant families, it is true, did hold on to leases for generations, the average tenure was quite less. In our sample, the average family (family here is defined very broadly and includes children, grandchildren, and in-laws) rented a farm for 19 years, or roughly one renewal of the average 9-year lease. Other studies reveal that large scale tenants in the Paris region actually had very high rates of geographic mobility and that they commonly moved and switched farms during their careers.<sup>33</sup> Their mobility would fit a world in which landlords easily introduced new tenants from other villages and in which old tenants did not cling to farms in the hopes of retaining a share of the profits. Those tenants who did linger were probably the best, retained by the landlord for their mutual benefit.

The large scale tenants in the Paris Basin also had large families, and while one could perhaps imagine collusion between two or three fermier patriarchs in order to depress local rents temporarily, the collusion would in all likelihood break down once the patriarchs tried to establish their numerous children on farms.<sup>34</sup> They would compete with one another to settle their children, and their heirs would do the same. Collusion, even if it existed, would be hard to maintain.

Finally, if tenant dynasties did in fact hold down rents and capture a share of the untaxed profits, then rent increases would have been significantly lower when the same tenant (or a relative) renewed a lease and significantly higher when a new tenant was finally installed. With our sample of leases, we can follow individual pieces of property from the end of the middle ages up to 1789, but never does rent behave in such a fashion. Such a result should not be surprising. Except in the regions of *mauvais gré*, nothing kept a landlord from eventually finding a new tenant, and with no barriers to entry, tenants could not long siphon off profits.

With a competitive rental market and frequent lease renewals--in the Paris Basin leases came typically came up for renegotiation every nine years, far more frequently than in much of early modern England--the leases and concomitant information on prices allow us to keep close track of the shifts in TFP. We need no other assumptions to calculate TFP. In particular, we need not assume that the supply of land was constant. Nor need we suppose that the farmers tilling the soil were profit maximizers, so long as we do not insist upon identifying variations in TFP with technical change. Most readers, undoubtedly, would consider profit maximization untenable for risk averse, early modern peasants, although, as it turns out, it is hardly an absurd assumption for the tenants who farmed for Notre Dame. Unlike sharecroppers, who split the risks of agricultural disaster with their landlord, they had taken on leases with large fixed rental payments and thus showed a willingness to confront the risks of farming alone. The pressures of the rental market would also push them to maximize profits, lest they be evicted in favor of more ruthless tenants. For them, even profit maximization is perhaps reasonable, and if so, then we can point to higher TFP as evidence of technical change.<sup>35</sup>

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above.

<sup>33</sup> Jean-Marc Moriceau, "Un système de protection sociale efficace: Exemple des vieux fermiers de l'Ile-de-France (XVIIe-début XIXe siècle)," *Annales de démographie historique* (1985), pp. 127-44.

<sup>34</sup> Ibid. See also the vivid portrait in the forthcoming book by Moriceau and Gilles Postel-Vinay.

<sup>35</sup> For the relationship between growth of TFP and technical change and the related issue of the functional form of the profit function, see the appendix. For TFP growth and technical change to be equivalent, it is also necessary that all the product and factor markets be competitive, which seems to have been the case. The effects of risk aversion on farming is covered in David M. G. Newbery and Joseph E. Stiglitz, *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk* (Oxford, 1981), while a argument in favor of profit maximization by Old-Regime farmers can be found in Philip T. Hoffman, "Institutions and Agriculture in Old-Regime France," *Politics and Society* 16(1988):241-64.



While the use of prices and leases to calculate TFP may now seem reasonable, one doubt may still linger in reader's mind. Accustomed to handling real physical quantities, he or she might like some reassurance that an index of TFP based on something so intangible as prices would really yield reliable results. Unfortunately, reliable physical measurements are almost always lacking. In one instance, though, where, thanks to an unusual set of family records, one can compare physical quantities produced and factors employed for a real eighteenth-century farm in the Paris Basin, the method of calculating TFP here gives extraordinarily accurate results. Neither the assumption of constant product and factor shares nor the use of prices in place of physical quantities seems to be misleading.<sup>36</sup>

### 3. Agricultural Productivity in the Paris Basin

What then do the leases reveal? The place to begin is with the evolution of TFP. It equals  $((r + t)/I)^s$ , where  $r$  is per-acre rent,  $t$  is per-acre taxes, and  $I$  is the price index. Under our assumption of constant factor shares,  $s$  turns out to be the land share in total cost. If we ignore taxes for the moment--an assumption to be corrected below--then the logarithm of TFP will be very nearly equal to  $s \log(r/I)$ . We can thus average  $s \log(r/I)$  across properties and get a near average of the logarithm of TFP. By calculating the average for different periods, we can then chart, at least roughly, changes in TFP.

Figure 2 graphs such an average for 25-year periods, beginning in 1525-49.<sup>37</sup> The years from 1450 to 1525 are excluded from the graph, because the prices in the index  $I$  become less reliable and the number of usable leases dwindles. At least in the parts of the Paris Basin that had suffered during the Hundred Years War, this earlier period had witnessed a recovery from the devastation wrought by conflict. Tenants reoccupied abandoned farms, rebuilt walls and barns, and cleared fields overgrown with weeds. The process of reconstruction swept on well into the sixteenth century, particularly in villages that were cursed with poor soil or situated far from Paris. As late as 1545, for example, Notre Dame was still clearing land in the village of La-Grande-Paroisse, 77 kilometers off to the southwest of Paris, where one of their tenants, Jean Godet, had to reclaim 9 hectares of briar-choked meadow. Godet also had to enclose the meadow with ditches in order to keep wandering animals out, evidence that the process had extended beyond mere rebuilding to become one of general improvement to the soil.<sup>38</sup>

If the wave of improvements persisted well into the sixteenth century, then it might explain the relatively high levels of TFP we observe in 1550-74 (Figure 2). Investment hidden in

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<sup>36</sup> The example, from data kindly furnished by Gilles Postel-Vinay, concerns a highly productive farm north of Paris. We can compare its productivity in the 1740s and in the 1780s using physical quantities and translog index--a so called superlative index--which assumes that the farmers were profit maximizers. With this technique we find that productivity on the farm rose 9.80 percent between the 1740s and the 1780s. If instead we use the price index  $I$  and shares adopted throughout the rest of this paper--shares that came from a model farm--we get very nearly the same thing, 9.45 percent. Employing constant shares calculated with data from the farm itself yields even closer results: either 9.72 or 10.09 percent, depending on whether we use the 1740s shares or the 1780s ones. In any case, it seems that our method (the one that gave the 9.45 percent) is very close to the sophisticated translog. Of course, this calculation itself involves a number of assumptions, any one of which could affect the results--how to treat entrepreneurial profits, etc. Changing the assumptions could have considerable effect on answers above, but fortunately they would always push the translog results and the naive results in the same direction. For a detailed analysis, see the appendix.

<sup>37</sup> Note that all properties, large and small, are counted equally in figure 2. Weighting them by their size does not change the graph appreciably.

<sup>38</sup> AN S407 (1464), S 272 (1522, 1545), S 409 (1479, 1482, 1483, 1498, 1511). Cf. Fourquin, *Campagnes*, pp. 389-97, 430-531, Map 5.

improvements would boost rents and thereby appear--somewhat erroneously--as higher TFP. It would also explain the high rates of change of TFP near the middle of the century, rates of change that are computed from lease to lease for individual properties (Figure 3). In 1525-49 TFP growth rates averaged 0.7 percent, a brilliant mark by early modern standards and one that compares favorably with the English performance.<sup>39</sup>

In all likelihood, however, the cause of the higher productivity in 1550-74 lies elsewhere, not in recuperation and improvements after the Hundred Year War. In the first place, information contained in the leases often allows us to deduct the portion of the rent that reflects improvements, at least when buildings are concerned. When it is deducted, however, the rent and consequently the TFP figures hardly change. One could argue that clearing and other investments in land would not figure in the leases, but land clearing is unlikely to have continued after 1550, particularly on properties close to Paris, where the level of TFP in 1550-74 turns out to have been largest. The farms near Paris had suffered much less during the Hundred Years War and they would in any case have been rebuilt long before in the fifteenth century, not after 1550 or even after 1525.<sup>40</sup> Evidently, some other force was pushing TFP upward in the mid sixteenth century, a force that waxed stronger near Paris. Perhaps it was the opportunity for specialization offered by proximity to a large city--a point to which we shall return below.

After the heights of mid century, TFP plummeted during the Wars of Religion. The rate of change of TFP also plunged, confirming the dismal picture at the close of the 1500s (Figure 3). Between 1550-74 and 1575-99, TFP fell over 5 percent, an enormous amount in early Europe, where even stunning agricultural productivity growth was eked out a few tenths of a percent per year. The cause of the collapse was undoubtedly war. The decline was most precipitous during and immediately after the years 1589-94, the period of most intense fighting in the Paris Basin, when undisciplined armies traversed the region, sowing devastation in their wake. It was during these accursed years when soldiers wreaked the greatest havoc. Not content to trample crops, seize livestock and grain, and burn farm buildings to the ground, they resorted to extortion and kidnapping and completely disrupted trade. Understandably, many a farmer fled, abandoning his farm to weeds or to pillage. Notre Dame's tenant, Bernaye, quit his lease in La Grande Paroisse in 1594 because of attacks by soldiers, and warfare left their farm in Dampmart abandoned and ruined in 1597. During the worst period of anarchy and plunder, TFP dropped by perhaps 19 percent.<sup>41</sup>

Such were the heavy consequences of war. To be sure, the index of TFP might seem ill suited for gauging the effects of such transitory events, since it was designed to measure only long term trends. Yet the evidence suggests that the plunge of TFP during the Wars of Religion was in fact real.<sup>42</sup> Curiously, although historians have paid lip service to the baleful influence warfare had on the agrarian economy of early modern Europe, they have tended to downplay it, at least insofar as late sixteenth and early seventeenth-century France is concerned. They prefer to view the disaster of the late sixteenth century as the initial episode of a long run crisis, a crisis whose true causes lie

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<sup>39</sup> For comparative purposes we might note that in the eighteenth century, when productivity growth in English agriculture seemed to be at a peak, the TFP growth rate--to be discussed below--was no more than 0.6 percent annually.

<sup>40</sup> Fourquin, *Les campagnes*, pp. 389-97, 430-531; Jacquart, *Crise rurale*, pp. 42-47.

<sup>41</sup> AN LL 329-30, La Grande Paroisse (1594); S 242 (25 June 1597); Jacquart, *Crise rurale*, pp. 171-207. The 19-percent decline in TFP comes from a regression reported below.

<sup>42</sup> The chief argument against the TFP figures would run something as follows: the siege of Paris in 1589-90 might have temporarily driven up the Paris prices that figure in our index I--thereby causing our measure of TFP to plunge erroneously--even though farm gate prices and true TFP in fact remained the same. But the index I averages prices for the current year and for the eight years of the previous lease; it is therefore unlikely to be swayed unduly by any single year of crisis. Furthermore, local markets show the same spike in prices in 1589-90 as does Paris, which suggests that the price increase was not confined to the city: Jacquart, *Crise rurale*, p. 765.

not in warfare or in evanescent political events, but in fundamental trends toward overpopulation, monetary disorder, and climatic change.<sup>43</sup> Without denying demography and meteorology their due, we can reply that such point of view neglects a concomitant and equally fundamental trend: the growth of the early modern state and of the armies it supported, armies that, as the episode of the Wars of Religion demonstrate, laid waste wherever they marched or camped.

The peaceful opening years of the seventeenth century brought a brief respite. Rates of growth increased and the average level of TFP began to rise. Then, toward the middle of the century, TFP stagnated or perhaps declined, depending on whether one examines average growth rates or levels (Figures 2 and 3). The lower levels of TFP might perhaps be taken to reflect the heavy taxes imposed to fund the kingdom's involvement in the Thirty Years War, for taxes were omitted from our calculation of TFP and the omission would artificially depress our index of TFP and its rate of growth. But if we correct for the resultant error in measurement, TFP growth rates remain nearly the same, both in the seventeenth century and in other periods (Figure 3).<sup>44</sup>

The correction here concerns only that portion of the farm profits or surplus that go to the fisc instead of to the landlord. But skyrocketing taxes could have also wreaked havoc by disrupting the agrarian economy. Tax increases pushed peasants into debt and led to the frequent seizure of livestock and other agricultural capital for the payment of back taxes. Along with troop movements during the Fronde and a series of bad harvests in the early 1630s, the tax-provoked disruptions fit the chronology of TFP's decline in 1625-49 and no doubt lay behind it.<sup>45</sup>

The following century brought stagnation or perhaps a slow recovery (Figures 2 and 3). If figure 3 is correct and there was a slow recovery, then part of it, at least, was a mirage, reflecting a decline in transportation costs rather than increased agricultural productivity. The cost of transport, we recall, drove a wedge between farm gate prices and Paris prices for bulky commodities such as grain and thus reduced rents as one moved away from the city. Since our calculation of TFP is based on Paris prices, and since the measure of TFP combines low local rents with high Paris grain prices, we undoubtedly underestimate the absolute level of TFP for farms distant from the city. The reason, again, is the simple fact that local rents adjust to transportation costs and local prices, not the higher prices prevailing in Paris.

As long as local grain prices moved in parallel with Paris--the usual pattern--there would be no cause for worry. Although absolute levels of TFP might err slightly, trends in productivity and rates of productivity growth would be the same. But over the course of the late seventeenth and early eighteenth centuries, local prices in markets such as Pontoise and Soissons rose slightly to approach those prevailing in Paris, and the gap between the Paris price and the local prices closed.<sup>46</sup>

What was happening undoubtedly was that transportation costs were declining. The increase in local prices relative to the Paris price was more pronounced the further one went from Paris, just as one would expect if the cost of transportation was falling. Such declining costs were themselves

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<sup>43</sup> Cf. Jacquart, *Crise rurale*, pp. 167-212; idem, "Immobilisme et catastrophes," *Histoire de la France rurale*, ed. Georges Duby and Armand Wallon, 3 vols. (Paris, 1975), 2:185-193; and the abundant literature on the Europe wide "crisis" of the seventeenth century.

<sup>44</sup> Since  $TFP = ((r + t)/I)^S$ , omitting taxes  $t$ , as we have, would tend to understate both the level and the growth rate of TFP, if taxes were rising relative to rents. Actual taxes for each piece of property will never be known precisely, but as is shown in the appendix we can use regressions on average tax indexes to tease out the magnitude of the resultant error. Because of multicollinearity we can only do this for growth rates, but Figure 3 demonstrates that the error involved is small.

<sup>45</sup> Jacquart, *Crise rurale*, pp. 623-99.

<sup>46</sup> Meuvret, *Subsistences*, vol. 3, pt. 2: 116-34; Baulant, "Le prix des grains"; AN F11 207 (Soissons price, corrected following the indications in Goubert, *Beauvais*, p. 408) and Dupâquier, *Mercuriales* (Pontoise price). Graphs of the Soissons and Pontoise prices show that they rose roughly 5 to 10 percent relative to the Paris price between 1650 and 1750; the increase was greater in Soissons than in Pontoise, which was closer to Paris.

a mark of increased productivity, but in transportation rather than farming.<sup>47</sup> Unfortunately, our measure of TFP would mistakenly confound the two. Rents would increase as local grain prices converged to the Paris price, but since we would be judging rents relative to a Paris price index I, it would seem that TFP was rising, particularly on distant farms, where the effect of declining transportation costs were most pronounced. It was precisely on such farms that the late seventeenth century recovery seemed most pronounced.

Prices in markets outside of Paris can reveal how much of the TFP recovery actually resulted from declining costs of transportation and from the concomitant rise in local prices. Let us consider, for instance, a market far from Paris, where the shift in grain prices relative to Paris was large. Soissons provides a perfect example: at over 100 kilometers from Paris, it was farther away than any property in our sample. Not surprisingly, the increase grain prices in Soissons relative to Paris account for 7.7 percent rise in our measure of TFP between 1650-74 and 1750-74, nearly all of the 8.5 percent gain we observe. But closer to Paris, the convergence of local prices to the Paris price has much less of an effect on our measurement of TFP. At a market such as Pontoise, a large and important trading center located approximately 30 kilometers from Paris, convergence of prices explains only a 3.7 percent increase in our TFP measure over the same period. Clearly, the Pontoise example is the one that is relevant to our sample of properties, which lay on average a little less than 40 kilometers from the city. Between 1650-74 and 1750-74, then, true agricultural TFP grew by only 4.8 percent--the other 3.7 percent we measure resulted from better transportation. The better transportation should of course not be slighted: it helped feed the growing city of Paris as much as did more efficient farms.

After the recovery and a long period of slow growth, TFP finally accelerated in the late eighteenth century (Figure 2). Between 1750-74 and 1775-89 it vaulted 7.3 percent, if we average across all properties. The spike at the end of the Old Regime stands out even more clearly if we look at rates of change (Figure 3). TFP growth, which had hovered in a narrow band about zero, accelerated to over 1 percent annually, a figure better than that achieved across the English Channel. Indeed, in the early 18th century, when productivity growth in English agriculture seemed to be at a peak, TFP was gaining only 0.6 percent annually, according to N. F. R. Crafts; later in the century, he estimates, the growth rate was only 0.2 percent. Robert Allen's work on the south Midlands points to a similar range: between 0.1 and 0.3 percent during the seventeenth and eighteenth centuries.<sup>48</sup> By comparison, agriculture in the Paris Basin seems positively buoyant.

But was the late eighteenth-century increase in TFP in the Paris Basin illusory? Did it, at least in part, mirror declining transportation costs, as with the slow growth in the years before 1750? The answer this time is no. In the first place, after 1775, our index of TFP rose no faster on distant properties than on those near Paris, the opposite of what one would expect with declining transport costs. Local prices, moreover, had by 1750 ceased rising relative to the Paris price, and their movement no longer accounts for any of the increase in TFP. Prices in Soissons explain perhaps a 1.7 percent increase in our measure of TFP between 1750-74 and 1775-89; those in Pontoise--the ones relevant to our sample--explain none at all.

The measure of TFP used here, it is true, may lag a bit behind reality. It took time to renew a lease, time to determine that a tenant was thriving and that the rent could be ratcheted upward. A wise landlord might wait before squeezing more out of his tenant, lest the tenant go bankrupt and the landlord receive nothing. Notre Dame, for example, investigated several tenants in the late 1750s, discovered that they were profiting and ruled out the prospect of bankruptcy. Only then did it raise

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<sup>47</sup> For direct evidence of declining costs of transportation, see J. Letaconnoux, "Les transports en France au 18 siècle," *Revue d'histoire moderne et contemporaine* 11(1908-09): 97-114, 269-92. Separating agriculture and transportation is somewhat artificial since much of the grain was carted to market by the farmers themselves. The declining costs of transportation undoubtedly stemmed from increasing specialization among the grain transporters.

<sup>48</sup> N. F. R. Crafts, *British Economic Growth during the Industrial Revolution* (Oxford, 1985), pp. 83-85; Robert Allen, "The Growth of Labor Productivity in Early Modern English Agriculture," *Explorations in Economic History* 25(1988): 117-46.

the rent. If such a pattern were general, the increase of productivity could have begun earlier than the graphs suggest.<sup>49</sup>

Whether the upturn began slightly earlier or not, there is nothing to suggest that the eighteenth-century jump in TFP was peculiar to the properties owned by Notre Dame. Rents (and hence TFP) rose by a similar order of magnitude throughout much of the Paris Basin in the late eighteenth century. Nominal rent increases of 90 to 120 percent between the 1730s and 1780s were common in Ile-de-France, Picardy, and the Beauce. On the Notre Dame's farms the increase was 97 percent. Indeed, the whole pattern traced by the rent and TFP figures from the Notre Dame sample parallels what we know from the leases of other properties, not just in the eighteenth century, but in the sixteenth and seventeenth centuries as well.<sup>50</sup>

Regressions of the logarithm of TFP and of its rate of change corroborate this three-century story of productivity change. If we regress the logarithm of TFP on soil quality, land use patterns, locational characteristics, and the other factors that affected rent and hence our index of TFP, we see that TFP did indeed plunge during the worst phase of the Wars of Religion. The coefficient of the dummy variable *dmwar*, which is 1 during the terrible years 1589-97 (the period of the most intense fighting around Paris plus the following 3-year crop cycle), translates into a 19 percent drop in TFP (Table 1, regression 1).<sup>51</sup> The regressions confirm that TFP stagnated thereafter, at least until the late eighteenth century: the coefficient of the year in the regression is only 0.02 percent. After 1775, however, TFP suddenly jumps 8.8 percent, to judge from the coefficients of the dummy variable *dm1775*, which takes on the value 1 for leases drawn up on or after 1775.

The large value for the condition number (a measure of problems with multicollinearity) gives cause for worry, but a regression with the rate of change of TFP, which is not afflicted with multicollinearity, points to the same dip in 1589-97 and to the same sharp increase after 1775 (Table 2, regression 1). The TFP growth rate fell 2.2 percentage points in 1589-97 and soared 1 point after 1775. In between it increased only slowly.<sup>52</sup>

The regressions convey more information as well, particularly if we also regress per-acre rent, suitably corrected for the variations in prices and wages (Table 1, regression 2). Soil quality has essentially no effect on rent and hence on TFP, a result in accord with evidence derived from nineteenth-century census records. Meadow, because of its scarceness near Paris, fetched a higher

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<sup>49</sup> AN S 242, 1754-62 (Dampmart); S 282, 1746-55, and S 460, 1782 (La Grande Paroisse).

<sup>50</sup> Béaur, Marché foncier, pp. 262-68; M. Bertrand-Lacabane, Brétigny-sur-Orge, Marolles-en-Hurepoix, Saint-Michel-sur-Orge (Versailles, 1886), pp. 314-15. The figures for TFP from the Notre Dame sample parallel almost exactly those that can be derived from the early seventeenth-century leases in Jacquart, Crise rurale, pp. 616, 638, 699. They also fit the pattern in Veyrassat-Herren and Ladurie, "La rente foncière", save in the eighteenth century, when the authors' sample shrinks to the point of unreliability.

<sup>51</sup> For the meaning of the variables in the various regressions see the glossary. The appendix lists the sources from which they were derived.

<sup>52</sup> For the condition number of the single value decomposition and multicollinearity, see D. Belsley et al, Regression Diagnostics (New York, 1980), and George G. Judge et al, The Theory and Practice of Econometrics, 2nd edition (New York, 1985), pp. 896-904. The sample, which combines time series and cross sections, shows no signs of heteroscedasticity, as one would expect with variables that are largely independent of farm size. And while simple tests of autocorrelation are not available (tests for time series-cross section autocorrelation assume that the time series are of equal length for each property), a property-by-property application of the Durbin-Watson test ruled out problems with simple autocorrelation. This was not only true of the regressions with the rate of change of TFP, which amounts to a first difference, but with  $\log(\text{TFP})$  as well.

rent; so did land closer to the city, because of the lower costs of transporting crops to the Paris market and higher farm gate prices.<sup>53</sup>

Like the analysis of local prices, the regressions argue against interpreting the increase in our TFP index exclusively as a decline in transportation costs. If falling transportation costs alone were to explain all the growth of our index of TFP--either the slow growth before 1750-74 or the rapid growth thereafter--then the rate of change of TFP would seem higher away from Paris. It would be on the distant properties that local prices would rise the most, and rents would follow in their wake. We would therefore expect to measure higher rates of TFP growth on distant properties and hence a positive coefficient for  $\ln \text{par}$  in the regressions of the rate of change of TFP (Table 2, regression 1). Yet such was not the case. The coefficient is negative, and while transportation was growing more efficient, farming did the same.<sup>54</sup>

The regressions also demonstrate that property size affected rent slightly, for large plots of land did rent for somewhat less, once we control for soil quality, land use, and location. A 100 percent increase in property area causes real rent to fall roughly 9.0 percent, according to the coefficient of  $\ln \text{area}$ , the logarithm of property size (Table 1, regression 2). Though consistent with tenant market power, the rent difference is not large and it also fits the argument that higher rents on small parcels were a risk premium to landlords. The coefficient of the variable  $\text{holdover}$ , which is 1 if one of the tenants was a holdover from the previous leases, also belies the existence of tenant market power. Had tenants commonly exercised power in the rental market, holdovers would depress the rent, yet nothing of the sort occurred (Tables 1, regression 2).

Even more telling are the regressions with the rates of change of TFP. Again, tenant holdovers should cut rent increases and hence our measure of TFP if tenants did indeed have monopsony powers; rents and our measure of TFP should rise significantly when new farmers were installed. In short, the coefficient of  $\text{holdover}$  should be negative and large in absolute value. While the coefficient does turn out to be negative, it is miniscule--only a tenth the size of the coefficient of  $\text{dml775}$ --and statistically insignificant (Tables 2, regression 1). In effect, retaining the same tenant cut the rent by only 0.4 percent, a sign that tenants exercised little monopsony power.<sup>55</sup>

What then explains the slow growth in TFP that we see before 1775 and the rapid increase thereafter? Even the surge after 1775 appears to be Smithian. No social or technological revolution shook the Paris Basin before 1789, and what change there was reflected gains from trade made possible by the proximity of Paris and of its growing market. The evidence thus fits the story, told

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<sup>53</sup> Grantham, "Agricultural Supply". A plentiful supply of manure near the Paris accounts for the minor role played by the variable  $\text{goodsoil}$ , but results in other regions might be very different. The appendix demonstrates how the per-acre rent is corrected for variations in prices. Ideally, one would want to have in the regressions a measure of the cost of shipping crops to Paris by the cheapest means available--overland for properties close to Paris, and by river for more distant properties, where the economies of river transport overtook the added costs of shipping crops to a river port and then loading them on boats. For the Paris area, though, evidence from the seventeenth and eighteenth centuries suggests that shipping costs were highly correlated with simple distance from Paris. Indeed, if one figures the cost of shipping to Paris via the cheapest means, its logarithm is nearly perfectly correlated with the logarithm of distance from Paris ( $r = 0.99$ ), and this correlation does not seem sensitive to errors in the shipping cost figures. Using distance from Paris rather than shipping costs therefore seems justifiable.

<sup>54</sup> Multicollinearity rules out adding an interaction term to the regressions in Table 2 in order to see if the coefficient of  $\ln \text{par}$  shifts in 1775-89. The coefficient of  $\ln \text{par}$  does remain negative, however, if we restrict ourselves to leases drawn up after 1700.

<sup>55</sup> One might be worried by the endogeneity of the variable  $\text{holdover}$ , but that can be ruled out using the test outlined in J. A. Hausman, "Specification Tests in Econometrics," *Econometrica* 46(1978): 1251-71. The regression results are similar if the variable  $\text{holdover}$  is also set equal to 1 when the current tenant is a relative of the previous one.

by several historians, that stresses the scope of markets in explaining agricultural performance before the technological upheavals of the late nineteenth century.

In the Paris region, where a large and growing market lay next door, we can begin to see how agriculture benefited from proximity to the city and from the resultant opportunities for specialization. The higher productivity of farming near Paris did not necessarily stem from dramatically higher yields--evidence about the evolution of yields in the Paris region is in any case unclear--but we know that it was at least in part a response to the increasing animal population in the city. The horses that pulled the newly invented carriages of the privileged and brought food to the officiers of the growing state drove up the price of forage and encouraged production of animal feed close to the city. Early on farmers planted artificial meadows to feed their own livestock and then carted their oats, straw, and hay to Paris. They might then return with loads of manure to spread on their fields, releasing them from the terrible constraint that the lack of fertilizer imposed on traditional agriculture and boosting their grain yields. These changes all tended to be piecemeal and they were all accomplished on a small scale--in the corner of a field here, on a parcel of land there--rather than on entire farms. Nonetheless, they sufficed to push TFP upward.<sup>56</sup>

The regressions corroborate the important role played by proximity to Paris and by the city's growth. Multicollinearity precludes adding the population of Paris to the regressions with the logarithm of TFP, but the rate of change of the Paris population has a large effect on the rate of increase of TFP (Table 2, regression 1). In the early seventeenth century, for example, when the population of Paris was gaining 1.3 percent annually--rapid growth by contemporary standards--it added 0.2 percent to the rate of increase of TFP, a large amount in the early modern world.<sup>57</sup>

Small farm size has been invoked to explain the failings of French agriculture ever since the days of Arthur Young, and it would be worth knowing whether farm size or consolidation affected TFP growth in the Paris area. The regressions appear to say no. Large size (as measured by the variable  $\ln area$ , the logarithm of property area) actually diminishes rent and thus our measure of TFP, but the effect, we have argued, is merely the risk premium demanded of small scale tenants (Table 1, regressions 1 and 2). If we add to the regression a somewhat crude measure of consolidation ( $\ln arpc$ , the logarithm of the number of hectares per parcel), it does seem to boost the level of TFP, but the coefficient could be an artifact of multicollinearity (Table 1, regression 3). More convincing perhaps are the rate of change regressions, where multicollinearity poses no problems. There, neither  $\ln area$  nor  $\ln arpc$  affects TFP's growth (Table 2, regressions 1 and 2).<sup>58</sup>

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<sup>56</sup> The previous two paragraphs depend upon Chevet, "Le Marquisat d'Ormesson"; George Grantham, "The Diffusion of the New Husbandry in Northern France, 1815-1840," Journal of Economic History 38(1978): 311-37; idem, "Agricultural Supply"; Jacquart, La crise rurale, pp. 321-330; Meuvret, Subsistences; and forthcoming work by Gilles Postel-Vinay. The link between horses and artificial meadows, which appeared early in the Paris region, was clear to contemporaries. In 1647, some thirty priests residing in the countryside near the capital complained that the phenomenal increase in the number of horses in the city during the past fifteen years had led to a planting of artificial meadows and cost the priests their tithe rights on grain. See Meuvret, vol. 2, pt. 2:59. The increase in the number of horses drove up the price of oats--and presumably hay as well--relative to wheat in both Paris and Pontoise. For inconclusive evidence about yields, see the discussion below.

<sup>57</sup> For the sake of comparison, the growth rate of Amsterdam's population reached a feverish 2 percent in 1600-50, while London's attained 1.8 percent in 1550-1600. Both were enormous by the standards of early modern Europe and not long sustained. See Jan de Vries, European Urbanization, 1500-1800 (Cambridge, Mass.; 1984), pp. 242, 270-71.

<sup>58</sup> Admittedly,  $\ln arpc$  is an imperfect measure of consolidation since what were counted as separate parcels could in fact be adjacent pieces of land. Inserting it in the  $\log(TFP)$  regressions aggravates the multicollinearity because it is correlated with  $\ln area$ --hence an even higher value of the condition number. If  $\ln arpc$  is used to replace  $\ln area$  in the  $\log(TFP)$  regression, its sign remains negative. Note that most of the other coefficients in the  $\log(TFP)$  regression are little

Yet we must be careful here. All that the rate-of-change regressions really imply is that no long-run obstacles blocked the enlargement or the consolidation of farms. To understand why, we must realize that properties were frequently consolidated by tenants who rented adjacent farms from different landlords. Although the farms were distinct properties, the tenant operated them together. When André-Paul Hanoteau and his wife leased Notre Dame's 30-hectare property in Le-Tremblay-lès-Gonesse in 1784, for example, it was not all the land they farmed. Indeed, they worked a total of several hundred hectares in Le Tremblay-lès-Gonesse and the surrounding area.<sup>59</sup> In the eighteenth century such arrangements--let us call them lease accumulation--grew common and seemed to capture economies of scale. They allowed a tenant to economize on buildings, equipment, and certain tasks.<sup>60</sup> Furthermore, his skills as an overseer--an important part of early modern farming--could then be spread over two farms.

Notre Dame had so much land that it could occasionally effect a consolidation by leasing two of its own properties to the same tenant. When we examine such consolidations, we find some failures but also some striking successes, as in La Grande Paroisse in the early seventeenth century, where TFP gained 6 percent.<sup>61</sup> Further evidence emerges from surviving rural tax rolls, which by the late eighteenth century routinely carried information about the total acreage a tenant farmed. The tax assessments in any given year turn out to be very nearly proportional to the total acreage the tenant worked and so can serve as a proxy for the amount of land under his direction. If we compare various tenants' tax assessments for two fixed periods, change in the assessments will then give a relative measure of the increases in the scale of their farming operations. To be sure, the overall tax rate will have changed over the intervening period, but the assessment increase will still yield a relative measure of how much more land a tenant farmed. If he takes on additional acres, his assessment will rise faster than the tax rate. If not, the assessment will merely keep pace with the tax rate.

Being able to rely upon the changes in tax assessments as a proxy for changes in farm scale lets us use the tax roles from the 1740s, when, at least near Paris, taxes still seemed proportional to the area a tenant farmed, even though the areas themselves rarely figured on the roles. For a small number of properties we can find tenants' assessments both in 1741 and in 1783-86.<sup>62</sup> If we plot how

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affected by the addition of  $\ln arpc$ . The only exceptions are the coefficient of  $\ln area$ , which is larger in absolute value (probably because of multicollinearity), and the coefficient of  $\ln vigne$ , which is also bigger. In the rate of change regression, adding  $\ln arpc$  also fails to disturb the coefficients in any serious way.

<sup>59</sup> Hanoteau died in 1785 and according to the tax roll of that year he farmed 224 hectares. Records of his estate suggest that he farmed even more--some 400 hectares. I thank Gilles Postel-Vinay and Jean-Marc Moriceau for furnishing this information.

<sup>60</sup> In the eighteenth century, Notre Dame wanted to suppress the buildings on properties now too small to be economical farms: AN LL 332 (1761-62, Larchant); S 320 (26-6-1780, Lizy-sur-Ourcq). One sign that lease accumulation was growing more common in the eighteenth century is that the leases begin to carry a clause acknowledging it: AN S324A (Le-Mesnil-Amelot, 25-6-1781), S 407 (Viercy, 25-8-1785). For early consolidation, see Jacquart, *Crise rurale*, pp. 340-48, and for an excellent example, see the forthcoming book by Postel-Vinay and Moriceau.

<sup>61</sup> AN LL 329-30, S 272, S 273 (1636-54).

<sup>62</sup> For the nature of tax roles in the election of Paris, see Jean Guerout, ed., *Rôles de la taille de l'élection de Paris conservés aux Archives nationales (sous séries Z 1G) et dans les archives départementales* (Paris, 1981). A search at the AN turned up tax assessments for 25 tenants in the series Z 1G, and these assessments bore out the close relationship between the size of the assessment and the acres the tenant farmed. Tax assessments may have been misleading in earlier periods and in other regions, but here they seem a reliable guide to the acreage farmed. For only



much the tax assessment changed for each property between 1741 and 1783-86 on a logarithmic scale versus how much the logarithm of TFP changed for the same property over the same period, the relationship between the scale of a tenant's operation and TFP stands out clearly, even though we are dealing with only six properties (Figure 4).

Again, the overall tax rate per acre had shifted between 1741 and 1783-86, but the change in taxes for a given property still yields a relative measure of how much more land the later tenant farmed. In Le-Tremblay-lès-Gonesse, for example, the scale of the tenant's operation grew appreciably between 1741 and 1783-86. Until 1741, a struggling Mathieu Bignon had been farming Notre Dame's property in Le-Tremblay, along with roughly 30 hectares of his own. But by the early 1780s, we know, the property was farmed by André-Paul Hanoteau, who worked much more land. The increased acreage had boosted the tenant's *taille* assessment appreciably in the intervening years, and the TFP of the property marched in step, climbing 14 percent.<sup>63</sup>

Apparently, consolidation via lease accumulation did increase productivity, evidence that farm size mattered. The fact that our measures of size and of consolidation had no noticeable positive effect in the rate-of-change regressions merely implies that the process encountered few obstacles, at least in the eighteenth century. Otherwise, the large properties, in effect already consolidated, would have had a great advantage, and the coefficients of *lnarea* and *lnarpc* would be large and positive.

Size and consolidation thus mattered, but at least near Paris there were few obstacles to achieving the appropriate scale. Perhaps this scale increased over time, particularly in the eighteenth century. It is true that attempts to consolidate before the eighteenth century often failed. And it is possible that the skills needed to run a large farm were scarce in the earlier centuries, when few farmers could mobilize the necessary capital or keep the requisite farm accounts.<sup>64</sup>

Weighing the various factors that contributed to the TFP gain in the eighteenth century is difficult, but we can at least advance some crude estimates. Of the 7.3 percent increase in TFP between 1750-74 and 1775-89, perhaps 1.6 percent resulted from the growth of Paris, if we judge from the regressions in Table 2. The rest probably reflected either the economies of scale realized during farm consolidation or the growth of grain yields. Unfortunately, assessing the relative importance of either scale economies or yields is difficult. Lease accumulation makes it nearly impossible to tell precisely how much the size of farms changed during the eighteenth century, and the evolution of yields about Paris is equally uncertain. On the one hand, Jean Meuvret and others have suggested that there was no increase in yields near Paris in the eighteenth century and hence no role for yields in the growth of TFP. On the other hand, George Grantham has proposed a 15-percent rise in wheat yields between 1750 and 1800, which translates into a 6.8 percent TFP gain and even more if the yields of other grains also rose. Such progress of yields would be enough, in and of itself, to explain nearly the entire productivity increase we observed in the late eighteenth century: 7.3 percent between 1750-74 and 1775-89, or 8.8 percent if we take the longer period beginning in 1725-49.<sup>65</sup>

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six of the properties, however, was I able to get leases and tax assessments in both 1741 and 1783-86. The six properties were in Dampmart, Epiais, Louvres, Le-Tremblay-lès-Gonesse, Villiers-sur-Marne, and Gentilly.

<sup>63</sup> AN Z 1G 292B (1741) and 431A (1786). Hanoteau died in 1785, forcing me to use his widow's tax assessment; using his own assessment for 1785 would not have changed matters appreciably. As with all the properties, the change in  $\log(\text{TFP})$  here was computed between the years 1732-45 and 1777-89. Such long periods had to be chosen because of the volatility of rent payments and because the leases in force in the years 1741 and 1783-86 had been drawn up as early as 1732 and 1777.

<sup>64</sup> For the capital and skills large farmers possessed in the Paris region, see Moriceau, "Système de protection" and the forthcoming work by Moriceau and Postel-Vinay.

<sup>65</sup> Meuvret, *Subsistences*, vol. 1, pt. 1:194-203; Morineau, *Les faux-semblants*; and George

Whatever the causes, it is in any case clear that Old-Regime agriculture was capable of astonishing growth, at least near Paris. To be sure, the region was perhaps the most commercialized part of France, and no other French city could generate the same opportunities for specialization. And perhaps the innovations that spurred on productivity growth--among them the planting of artificial meadows and the consolidation of properties--faced fewer obstacles in the Paris region than they did elsewhere. Nonetheless, the performance of agriculture near Paris is still stunning and far better than critics have alledged. As early as the sixteenth century, local farmers managed to outdo their English counterparts, and the progress they achieved was particularly dramatic in the late eighteenth century--not what is usually expected on the eve of the Revolution.

Overall, the pattern traced by agricultural productivity did not betray the workings of population growth and diminishing returns, as scholars such as Emmanuel Le Roy Ladurie have maintained.<sup>66</sup> When the population of the region peaked in the middle of the sixteenth century, productivity was high, not low as diminishing returns would suggest. When productivity fell much later in the century, the cause was war, not population change, for the population was if anything declining. Thereafter too TFP danced to a rhythm set not by regional population growth, but by other factors altogether. Among them we must count the beneficent effects of political peace and the opportunities for trade and specialization available on the outskirts of a large city.

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Grantham, "The Growth of Labour Productivity in the 'Cinq Grosses Fermes' of France, 1750-1933," in Bruce Campbell and Mark Overton, eds., Productivity Change and Agricultural Development (Manchester, forthcoming). Obviously, part of the growth in yields was itself a result of the growth of the city.

<sup>66</sup> Cf. Ladurie, French Peasantry, pp. 7-20, 95-96, 186, 267-269, 277, 306-07. More recent population figures for France and for the Paris Basin in Jacques Dupâquier et al, Histoire de la population française, 4 vols. (Paris, 1988), 2:52-67, 164-65, do not fit the productivity trends any better than those used by Ladurie. It should be noted, though, that Ladurie considers the Paris Basin something of an exception.

# Appendix

## 1 Treatment of Leases

In addition to annual cash rent, the leases included in-kind payments, *pots-de-vin* (entry fines, almost always equal to a one-time payment of ten percent of a year's rent), and *charges* (obligations to make cash or in-kind payments for Notre Dame—to a local priest, for example). I spread the *pots-de-vin* evenly over the life of the lease and converted the in-kind payments into cash. If the in-kind payments entailed delivering grain to Paris (the usual case), they were evaluated using the average Paris price on the feast of Saint Martin—November 11, the day when most payments were due—over the course of the previous lease (i.e., the current feast of Saint Martin and the eight previous ones). For wheat and rye, minimum Saint Martin prices were used since Notre Dame expected the grain to fetch a price slightly less than the best quality wheat and rye. For the oats and barley only maximum prices were available, but most in-kind payments involved wheat. After 1698 the Saint Martin wheat prices in Paris ceased being available, so I used a proxy constructed by first regressing the Saint Martin wheat prices on the annual Paris wheat price for the years before 1698 and then projecting the relationship forward into the eighteenth century. Saint Martin prices were also lacking for the other grains after 1698, which necessitated similar proxies. For rye I regressed Paris Saint Martin rye prices on the annual Paris wheat prices and projected the relationship forward, while for barley and oats, I simply used annual Paris prices for barley and oats.

Grain delivered outside of Paris and other in-kind payments—usually very small—were evaluated using cash equivalents found in late eighteenth-century leases. I projected the late eighteenth-century-cash equivalents into the past using long-term trends in the prices of the items concerned. If the cash equivalents were unavailable, I relied on prices in markets near the property in question. One might wonder, of course, whether the results were sensitive to the way I evaluated the in-kind payments, but this seems not to have been the case. Regressions with leases where all the payments were in cash differ little from regressions done with the in-kind leases, except for a higher  $R^2$ . The reason for the higher  $R^2$  with the cash-only leases was that the value of grain payments was volatile and added considerable noise to the dependent variable in the regressions.

Notre Dame employed *contre lettres* (private letters attached to the leases) to revise its leases, but unlike other landlords, Notre Dame never used them to raise the rent. In the hands of other landlords *contre lettres* served to reduce their large-scale tenants' tax assessments because the tax assessment would be based on the lower rent in the lease, not on the higher rent in the *contre lettre*. Notre Dame, though, never resorted to such practices. The reason was undoubtedly that working a large farm for Notre Dame typically involved paying sizable *charges*, typically to the local parish priest. Since these charges did not figure in the tax assessments either, the large scale tenant of Notre Dame automatically had a tax reduction equivalent to that gained by other landlords via the

*contre lettres.*

In addition to farm land, the Notre Dame leases might also involve rights to collect the tithe or seigneurial dues on property other than the land that was to be cultivated by the tenant. Since these rights did not pertain to the operation of the farm, I subtracted their value from the lease. I determined their value from cash equivalents given in the late-eighteenth century, suitably adjusted for changing prices. For none of the properties were such tithes or seigneurial dues large. If they or the property area changed by a significant amount (for example, more than a 14-percent change in the property area), I assumed that I was dealing with a different property and began a new-time series.

## 2 Formulas for TFP

Assume the farmer produces outputs  $y_1, \dots, y_m$  using factors of production  $x_1, \dots, x_n$ , where  $x_1$  is land. If the outputs can be sold at prices  $p_1, \dots, p_m$  and the factors of production purchased at prices  $w_1, \dots, w_n$ , then the farmer's profit is

$$P = \sum_{i=1}^m p_i y_i - \sum_{j=1}^n w_j x_j \quad (1)$$

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Although some of the farmer's transactions may have taken place outside markets, we assume that he was at least partially involved in the product and factor markets, so that the prices in (1) are market prices.

If the land rental market is competitive with free entry and if rents are revised frequently, then  $P$  will be driven down to zero: all profits will go to landlords. Therefore,

$$\sum_{i=1}^m p_i y_i - \sum_{j=1}^n w_j x_j = 0 \quad (2)$$

Differentiating the left-hand side of (2) with respect to time and regrouping all the terms, we obtain

$$\sum_{i=1}^m p_i \frac{dy_i}{dt} - \sum_{j=1}^n w_j \frac{dx_j}{dt} = \sum_{j=1}^n \frac{dw_j}{dt} x_j - \sum_{i=1}^m \frac{dp_i}{dt} y_i \quad (3)$$

Dividing through by total revenue or cost  $R = \sum_{i=1}^m p_i y_i = \sum_{j=1}^n w_j x_j$  yields

$$\sum_{i=1}^m u_i \dot{y}_i - \sum_{j=1}^n v_j \dot{x}_j = \sum_{j=1}^n v_j \dot{w}_j - \sum_{i=1}^m u_i \dot{p}_i \quad (4)$$

where the  $u_i = \frac{p_i y_i}{R}$  are output shares in total revenue, the  $v_j = \frac{w_j x_j}{R}$  are factor shares in total cost, and the dots refer to logarithmic rates of change ( $\dot{y}_i = \frac{d}{dt} \log y_i$ , etc.). The expression on the left is the rate of change of TFP, which we shall call  $\dot{T}$ . It is the rate at which outputs are growing less the rate at which inputs are increasing, suitably weighted by output and factor shares. Equation (4) simply allows us to calculate  $\dot{T}$  using prices instead of quantities, and it is the basis for our calculations of the rate of change of TFP in Figure 3 and Table 2.

So far we have only assumed that markets exist and that one of these markets, the land-rental market, is competitive and open to entry. This assumption allows us to set profits equal to zero and makes the tenant's compensation no more than he would earn in the labor market. Although such a treatment of farmer profits is obviously open to question—a subject to which we shall return below—it is standard in the agricultural productivity literature.<sup>1</sup>

If product and factor shares are constant, then, by integrating  $\dot{T} = \sum_{j=1}^n v_j \dot{w}_j - \sum_{i=1}^m u_i \dot{p}_i$  with respect to time, we have that

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$$T = \frac{w_1^{v_1} \dots w_n^{v_n}}{p_1^{u_1} \dots p_m^{u_m}} \quad (5)$$

where  $T$  is an index of TFP. To adopt the notation used in the body of the paper,

$$T = \left( \frac{r}{I} \right)^s \quad (6)$$

where  $r = w_1$  is per-acre rent,  $s = v_1$  is the land factor share, and  $I$  is an index of the prices of products and of factors of production other than land.  $I$  is defined via

$$I = \frac{p_1^{u_1/v_1} \dots p_m^{u_m/v_1}}{w_2^{v_2/v_1} \dots w_n^{v_n/v_1}} \quad (7)$$

By (6),

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<sup>1</sup>See the criticisms in G. R. E. Lopez, "Estimating Substitution and Expansion Effects Using a Profit Function Framework", *American Journal of Agricultural Economics* 66 (1984): 358-67

$$\log\left(\frac{r}{I}\right) = \frac{1}{s} \cdot \log(T) \quad (8)$$

Since  $\frac{r}{I}$  is rent correct for changes in prices, we see that its logarithm is simply a multiple of the logarithm of TFP, and  $\frac{1}{s} \log(T)$  will serve as index of the logarithm of real rent. Equation (6) is the basis both for the variable graphed in Figure 2 and for the dependent variable in Table 1, regressions 1 and 3. Equation (8) yields the dependent variable in Table 1, regression 2.

Essentially, equations (4), (5) and (6) correctly adjust rent levels for changing prices. If, for instance, the rent on a particular farm increases, but the prices of agricultural products and the factors of production remain the same, then TFP, we know from (4) or (6), must have increased. On the other hand, if TFP remains static while prices shift, then rents will change, but just enough to keep

$$\dot{T} = \sum_{j=1}^n v_j \dot{w}_j - \sum_{i=1}^m u_i \dot{p}_i = 0 \quad (9)$$

In this instance, the index of TFP,  $\left(\frac{r}{I}\right)^s$  will also stay the same. This would be the case, for example, if a growing population drove wages down relative to agricultural prices and pushed rents up. If TFP were constant while the population grew, then the change in rents would exactly compensate for the change in prices and wages, leaving the ratio  $\left(\frac{r}{I}\right)^s$  fixed. Note that this method of correcting rents for changing prices is far superior to the traditional practice of deflating with the price of wheat, which is usually done in order to gauge what rents will purchase. Not only would rentiers of course be unlikely to purchase much wheat, but the resultant index is no guide at all to agricultural productivity, or even to the marginal product of land.

If our farmers maximize profits and if all the product and factor markets are competitive—not just the rental market—then we can say more. We assume that our farmer takes all the prices  $w_j$  and  $p_i$  as given and that the inputs and outputs are linked via a transformation function  $F$  with  $F(x_1, \dots, x_n, y_1, \dots, y_m, t) = 0$ .<sup>2</sup> Here  $F$  depends on time  $t$  because of technical change. If the technology is well behaved, we can use the implicit function theorem to solve for one output (say  $y_1$ ) in terms of  $x_1, \dots, x_n, y_2, \dots, y_m, t$ , so that at least locally

$$y_1 = f(x_1, \dots, x_n, y_2, \dots, y_m, t)$$

Differentiating this expression with respect to time, we have

<sup>2</sup>For the necessary assumptions, see Chambers, *Applied Production Analysis*, pp. 260-61.

$$\begin{aligned}
\frac{dy_1}{dt} &= \frac{\partial f}{\partial x_1} \frac{dx_1}{dt} + \dots + \frac{\partial f}{\partial x_n} \frac{dx_n}{dt} + \frac{\partial f}{\partial y_2} \cdot \frac{dy_2}{dt} + \dots + \frac{\partial f}{\partial y_m} \frac{dy_m}{dt} + \frac{\partial f}{\partial t} \\
&= \frac{w_1}{p_1} \frac{dx}{dt} + \dots + \frac{w_n}{p_1} \frac{dx_n}{dt} - \frac{p_2}{p_1} \frac{dy_2}{dt} - \dots - \frac{p_m}{p_1} \frac{dy_m}{dt} + \frac{\partial f}{\partial t}
\end{aligned} \tag{10}$$

by the first-order condition for profit maximization with competitive markets. Multiplying both sides by  $\frac{p_1}{R}$ , where  $R$  is total revenue, yields, after terms are rearranged:

$$\dot{T} = \sum_{i=1}^m u_i \dot{y}_i - \sum_{j=1}^n v_j \dot{x}_j = u_1 \dot{f} \tag{11}$$

where  $\dot{f} = \frac{\partial}{\partial t} \log f$ . Here  $u_1 \dot{f}$  is the rate of technical change, the rate at which the production function  $f$  is shifting, adjusted for the relative importance of the output  $y_1$ . With only one output, for example,  $u_1 = 1$  and  $T$  equals  $\dot{f}$ . Note that this result does not depend on factor and product shares being constant.

In the context of profit maximization, the assumption of constant product and factor shares amounts to a choice of the form of the profit function. The particular form implied by the constant shares assumption is only a local first-order approximation to an arbitrary profit function. Obviously, a functional form capable of providing a local second-order approximation (so-called flexible-functional forms, such as a translog or a generalized Leontief) would be preferable, but the data needed to estimate such profit functions (and thereby determine TFP) is unfortunately unavailable, because the estimation requires information on both prices and quantities.<sup>3</sup> As we shall see below, though, the loss in accuracy is minimal.

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<sup>3</sup>For the form of the profit function with constant shares, see Allen, "Efficiency and Distributional Consequences." On multi-output-profit functions, see Chambers, *Applied Production Analysis*, pp 268-81; Lawrence J. Lau, "Applications of Profit Functions," in Melvyn Fuss and Daniel McFadden, eds, *Production Economics: A Dual Approach to Theory and Applications*, 2 vols. (Amsterdam, 1978), 1 : 133-310; W. E. Diewert, "Applications of Duality Theory," in Michael D. Intriligator and David A. Kendrick, eds., *Frontiers of Quantitative Economics*, vol. 2 (Amsterdam, 1974), pp 107-71. One could try to estimate a flexible functional form profit function by regressing profits on prices, but the result would be doomed to failure by the large number of coefficients and the collinearity of the prices, as attempts with early modern data show. The only way around this problem is to simultaneously estimate derived supply and demand equations, which requires information on quantities. For an example, see Lopez, "Estimating Substitution and Expansion." Superlative index numbers—another way to calculate TFP and one equivalent to the use of a flexible functional form for the profit function—also require quantities. Cf. Robert C. Allen, "Recent Developments in Production, Cost and Index Number Theory, with an Application to International Differences in Cost and Efficiency of Steelmaking in 1907/9," in Rainer Fremdling and Patrick O'Brien, eds., *Productivity in The Economies of Europe* (Stuttgart, 1983), pp 90-99; idem and W. Erwin Diewert, "Direct versus Superlative Index Number Formulae," *Review of Economics and Statistics* 53 (1981) : 430-35; Douglas W. Caves, et al, "Multilateral Comparisons of Output, Input and Productivity using Superlative Index Numbers," *The Economic Journal* 92 (1982) : 73-86.

### 3 Treatment of Taxes

So far we have ignored taxation. If the burden of taxation falls on land—a reasonable assumption—then  $w_1$ , the cost of land, will include both per-acre rent  $r$  and per-acre taxes  $t$ :  $w_1 = r + t$ , and TFP will equal  $\left(\frac{r+t}{I}\right)^s$ . Let  $\frac{r}{r+t} = g$ , the fraction of  $w_1$  that goes to the landlord rather than to the fisc. Note that the tax rate as a percent of gross rent is simply  $1 - g$ . Since  $r + t = \frac{r}{g}$ , we have that

$$\begin{aligned}\log(T) &= \log\left(\frac{r+t}{I}\right)^s \\ &= s \log\left(\frac{r}{gI}\right) \\ &= s \log\left(\frac{r}{I}\right) - s \log(g)\end{aligned}\tag{12}$$

Similarly

$$\dot{T} = s(\dot{r} - \dot{I}) - s\dot{g}\tag{13}$$

We know  $s, r, I, \dot{r}$ , and  $\dot{I}$ , so all we have to do is to subtract  $s \log(g)$  or  $s\dot{g}$  to correct our measured TFP figures for taxes. Note that if the tax rate  $1 - g$  as a percent of gross rent is constant, then  $g$  is constant and the tax correction amounts to adding a constant to  $\log(TFP)$  and no change at all to  $\dot{T}$ .

Unfortunately, we do not know  $g$  precisely, and it probably varied from property to property. One reasonable assumption is that for any given property  $i$ ,

$$\log(g) = a \log\left(\frac{\bar{t}}{\bar{r}}\right) + b_i\tag{14}$$

where  $a < 0$  is a constant,  $\bar{r}$  is the average per-acre rent in the region,  $\bar{t}$  is the average per-capita tax assessment, and  $b_i$  is a constant that varies from property to property. All equation (14) says is that taxes were apportioned with an eye toward average rent and average population levels and that while tax rates varied from property to property they also rose and fell with average-tax assessments and average-rent levels.

Note that



$$\dot{g} = a \frac{d}{dt} \log \left( \frac{\bar{t}}{\bar{r}} \right) \quad (15)$$

Suppose we have a relationship involving the rate of change of TFP,  $\dot{T}$ , and various explanatory variables  $z_1, \dots, z_k$

$$\dot{T} = c_1 z_1 + \dots + c_k z_k$$

Then by (13), we have

$$\begin{aligned} s(\dot{r} - \dot{I}) &= s\dot{g} + c_1 z_1 + \dots + c_k z_k \\ &= sa \frac{d}{dt} \log \left( \frac{\bar{t}}{\bar{r}} \right) + c_1 z_1 + \dots + c_k z_k \end{aligned} \quad (16)$$

$s(\dot{r} - \dot{I})$  is just what we would measure as the rate of change of TFP if we ignored taxes. All we need do is regress  $s(\dot{r} - \dot{I})$ , which we can observe, on  $\frac{d}{dt} \log \left( \frac{\bar{t}}{\bar{r}} \right)$ , which we can also measure, and on the variables  $z_1, \dots, z_k$ . We will then recover the coefficients in the true relationship between  $\dot{T}$  and  $z_1, \dots, z_k$ , and the coefficient of  $\frac{d}{dt} \log \left( \frac{\bar{t}}{\bar{r}} \right)$  will be  $sa$ , which we can use to correct the observed rate of change of TFP,  $s(\dot{r} - \dot{I})$ , for the effects of taxation via

$$\begin{aligned} \dot{T} &= s(\dot{r} - \dot{I}) - s\dot{g} \\ &= s(\dot{r} - \dot{I}) - sa \frac{d}{dt} \log \left( \frac{\bar{t}}{\bar{r}} \right) \end{aligned} \quad (17)$$

In the regressions in Table 2,  $dtr$  is simply  $\frac{d}{dt} \log \left( \frac{\bar{t}}{\bar{r}} \right)$ , calculated from a national average per-capita tax rate by decade and average decade nominal rents. The coefficient of  $dtr$  then allows us to correct the observed rate of change of TFP for taxes via equation (17). The correction turned out to be minor since the tax rate did not vary greatly: taxes did rise, but so did nominal rents. Multicollinearity rules out adding the analogous term to the regressions in Table 1 so that the actual levels of TFP could be corrected for taxes. Since the tax rate did not vary greatly, though, the correction would in all likelihood be little more than the addition of a constant.

## 4 Factor and Product Shares and Robustness of the Method

The product and factor shares that serve as price weights in the calculation of TFP were derived from accounts and descriptions of typical farms in the Paris area. The sources included Charles Rebeyrol, *De la grande culture et de la petite culture chez les physiocrates* (Paris, 1912), pp 35-43; Tessier, *Agriculture*; Emile Mireaux, *Une province française au temps du grand roi: La Brie* (Paris, 1958); M. Jouvencel, *Modèle de bail à cheptel pour servir d'instruction aux propriétaires ou capitalistes qui voudront établir des troupeaux de bêtes à laines dans les fermes des environs de Paris* (Versailles, 1810); and S. Hassenfratz, "Mémoire sur la comparaison des produits de la culture du Bourbonnais avec celle de la Picardie," *Mémoires d'agriculture, d'économie rurale et domestique* (1786), pp 105-22. The sources yielded the following factor shares: labor, including in-kind compensation and labor provided by the tenant farmer, 0.319; rental price of horses, 0.039; rental price of cattle, 0.014; rental price of sheep, 0.046; rental price of pigs, 0.010; rental price of poultry, 0.011; rental price of equipment, 0.031; wheat seed, 0.052; rye seed, 0.008; barley seed, 0.006; oat seed and feed, 0.211; bean seed, 0.011; linseed, 0.004; land, including taxes, 0.237. Product revenue shares were as follows: wheat output, 0.456, rye output, 0.080; oats output, 0.100; barley output, 0.036; beans output, 0.073; flax output, 0.051; dairy products, 0.035; wool, 0.042; eggs, 0.015; beef, 0.012; mutton, 0.076; pork, 0.015; horses, 0.007. Rental prices of livestock and equipment were calculated using depreciation rates, an interest rate, and average sale prices. Seed and feed prices were multiplied by 1 plus the interest rate because they had been stored for a year. Only net inputs and net outputs were considered, although we did assume the purchase of seed and oat feed. Products consumed on the farm in the form of in-kind wages were evaluated at market prices.

One could easily find farms where some of the above items were not used or produced and where the factor shares were different. Yet on the whole the factor and product shares above seem reasonable. They agree with what one can deduce from the rare share contracts in the Paris region, and they fit the shares and descriptions given in other sources from the sixteenth, seventeenth, and eighteenth centuries including Jacquart, *Crise rurale*, pp 289-408; Meuvret, *Subsistances*, vol. 1; and forthcoming work by Postel-Vinay and Moriceau.

Despite some slight evolution, the shares seem not to have varied greatly over time in the Paris region. Hence the constant shares assumption appears reasonable. Even if the shares did change from farm to farm or over time, the fact that they serve to weight prices that are themselves highly correlated means that any error introduced by a change in shares will be minor. If on a particular farm or at a particular moment the shares were not precisely those given above, the price index would nevertheless be close to the truth because the prices that the shares combine are correlated.

We can see this clearly if we compare the above weights to those derived from a different source. Data in a forthcoming study by Gilles Postel-Vinay and Jean-Marc Moriceau can be used to derive a second set of product and factor shares. Despite some differences of method (certain factors and products had to be aggregated and seed had to be treated differently), the resultant shares are close, at least on an aggregate level, to those derived from my sources. It is thus no surprise that a price index calculated with the shares from the Postel-Vinay and Moriceau data is highly correlated with the index used in the text of the paper ( $r = 0.972$ ). Similarly, the measures of TFP calculated with the two sets of shares are highly correlated ( $r = 0.988$ ), as are the measures of the rate of change of TFP ( $r = 0.968$ ). Both sets of shares yield similar graphs of the path taken by TFP and by its rate of change, and both produce similar regression results.

The product and factor shares are thus relatively insensitive to the sources used, and different shares, in any case, lead to similar results. One might still worry, though, about the constant shares assumption and about the use of a first-order approximation to the profit function. Could such naive methods lead us astray in our calculation of TFP?

The one instance where we have the necessary data suggests that the answer is no. As explained in the body of the paper, the data (kindly furnished by Gilles Postel-Vinay) concerns a highly-productive farm north of Paris. We can compare its productivity in the 1740s and 1780's, and if we do so using a translog productivity index—one consistent with changing shares and with a second-order approximation to the profit function—the TFP change is still very close to that given by our naive methods: 9.80 percent with the translog index versus 9.45 percent with the naive method and with the shares used in the text of the paper. Most of the gap between the 9.80 percent and our 9.45 figure stems from differences between the particular farm north of Paris on which the calculation is based and the farms and descriptions that serve as the basis of our own shares. Very little of the difference between the two numbers results from the constant shares assumption. Indeed, if we use the shares prevailing on this one farm north of Paris in the 1740s and perform the naive TFP calculation with them, we get a TFP increase of 9.72 percent. The difference between 9.72 percent and 9.80 percent is what can be attributed to the constant shares assumption.

To be sure, this calculation involves a number of assumptions. In particular, profits, which were large on the farm north of Paris, were lumped together with payments to labor. Ideally, one would prefer to treat these as the price paid for an entrepreneurial input. If we had prices for the entrepreneurial input, we could recalculate TFP, and the results would change and probably increase. However, the change would push both the translogs results and the naive results in the same direction, and there would still be little difference between them.

## 5 Sources and Calculations of Variables

TFP and its rate of change were calculated using equations (4) and (6). For the highly volatile grain prices I used a nine-year moving average of the prices prevailing in Paris on the feast of Saint Martin in the year the lease was signed and in the eight previous years—in other words, prices averaged over the current year and the life of the previous lease. When Saint Martin prices ceased being available after 1698, I constructed proxies. For wheat I regressed the Paris Saint Martin wheat price on the annual Paris price and projected the relationship forward into eighteenth century. For the other grains, I proceeded in an analogous fashion, regressing the Paris Saint Martin prices on the Pontoise Saint Martin prices.

The cost of labor also involved a nine-year moving average: it was based on the average wage of unskilled-day laborers in Paris for the current year and the eight previous years. A similar average was used to calculate the rental price of equipment. The rental price was set equal to the interest rate plus depreciation times the sale price, and I assumed that the sale price of equipment rose proportionately with wages.

For the other prices there was too much missing data to construct nice annual series. What I did, therefore, was to average the available data for 25-year periods beginning in 1450-74. I then interpolated between the midpoints of each 25-year period to get an annual series from which I constructed nine-year moving averages.

The results were somewhat sensitive to the way in which the moving averages were constructed. If the moving averages are simply replaced with current prices, the value of  $\log(\text{TFP})$  one gets is still correlated with the original value ( $r = 0.805$ ), but the new and old rates of change of TFP are only slightly correlated ( $r = 0.338$ ). Still, the overall pattern traced by the evolution of TFP and of its rate of change remain the same, and the regressions are not greatly different. The only difference is that the TFP gain at the end of the eighteenth century is even more pronounced if we use current prices. The volatility of grain price explains the difference between the results when TFP is calculated with current prices and when it is calculated with moving averages, and it seemed reasonable to average in order to smooth out the grain price volatility.

The explanatory variables in the regressions were derived using information in the leases and associated property descriptions. For DTRAT, the index of per-capita taxation  $\bar{t}$  for the years after 1560 was calculated using decennial averages based on population figures and central treasury receipts from Table 1 of Philip T. Hoffman, "Fiscal Crises, Liberty and Representative Government: The Case of Early Modern France," (forthcoming). For the period before 1560, I spliced the series of central treasury figures to *taille* levels given in J. J. Clamageran, *Histoire de l'impôt en France*, 3 vols. (Paris, 1867-76) and used population figures in Dupâquier, *Histoire de la population française*, 1:513-24, 2:51-68, interpolated and adjusted for changes in frontiers. A local tax series would have been preferable to the central treasury and *taille* figures, but a suitable series does not

exist.

For DPARPOP I relied upon a variety of sources, including Jean-Noël Biraben and Alain Blum, "Population Trends in France, 1500-1800: Comparison With Other Countries", (forthcoming); Marcel Lachiver, "L'approvisionnement de Paris en viande au XVIIIe siècle", in *La France d'ancien régime: Etudes réunies en l'honneur de Pierre Goubert*, 2 vols. (Paris, 1984), 1:345-54; Dupâquier, *Histoire de la population française*; E. Charlot and J. Dupâquier, "Mouvement annuel de la population de Paris de 1670 à 1821," *Annales de démographie historique* (1967), pp 511-19; and a data base put together by Philip Benedict. The destruction of records makes estimating the population of Paris difficult, but Benedict has assembled what seem to be the most reliable estimates. In a forthcoming article he faults the accuracy of the Paris population figures in the *Histoire de la population française*, and I have therefore relied upon his numbers and upon those in the articles by Biraben, Charlot and Lachiver in making my estimates.

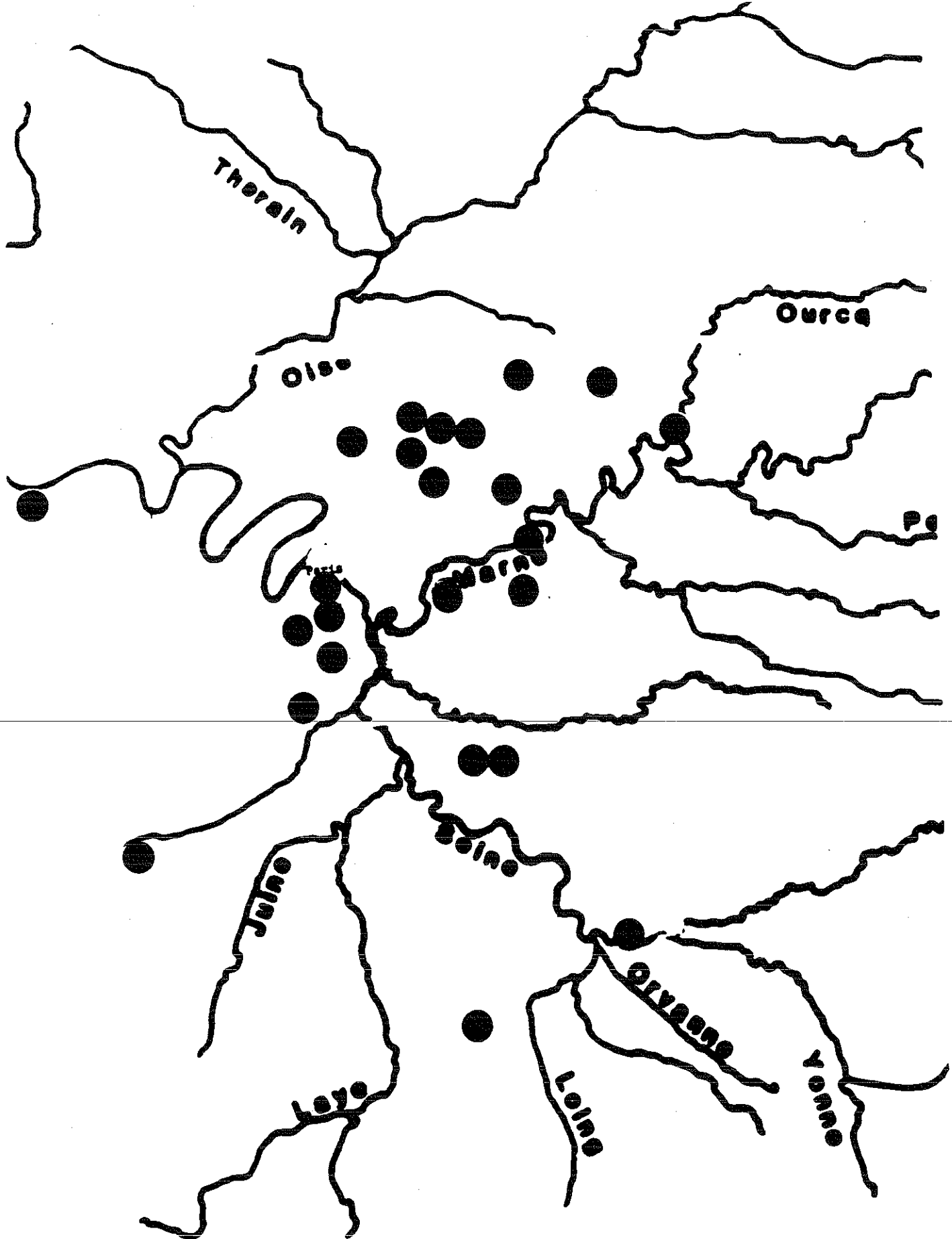


FIGURE 1

Figure 2: The Logarithm of TFP  
(1750-74 set equal to 0)

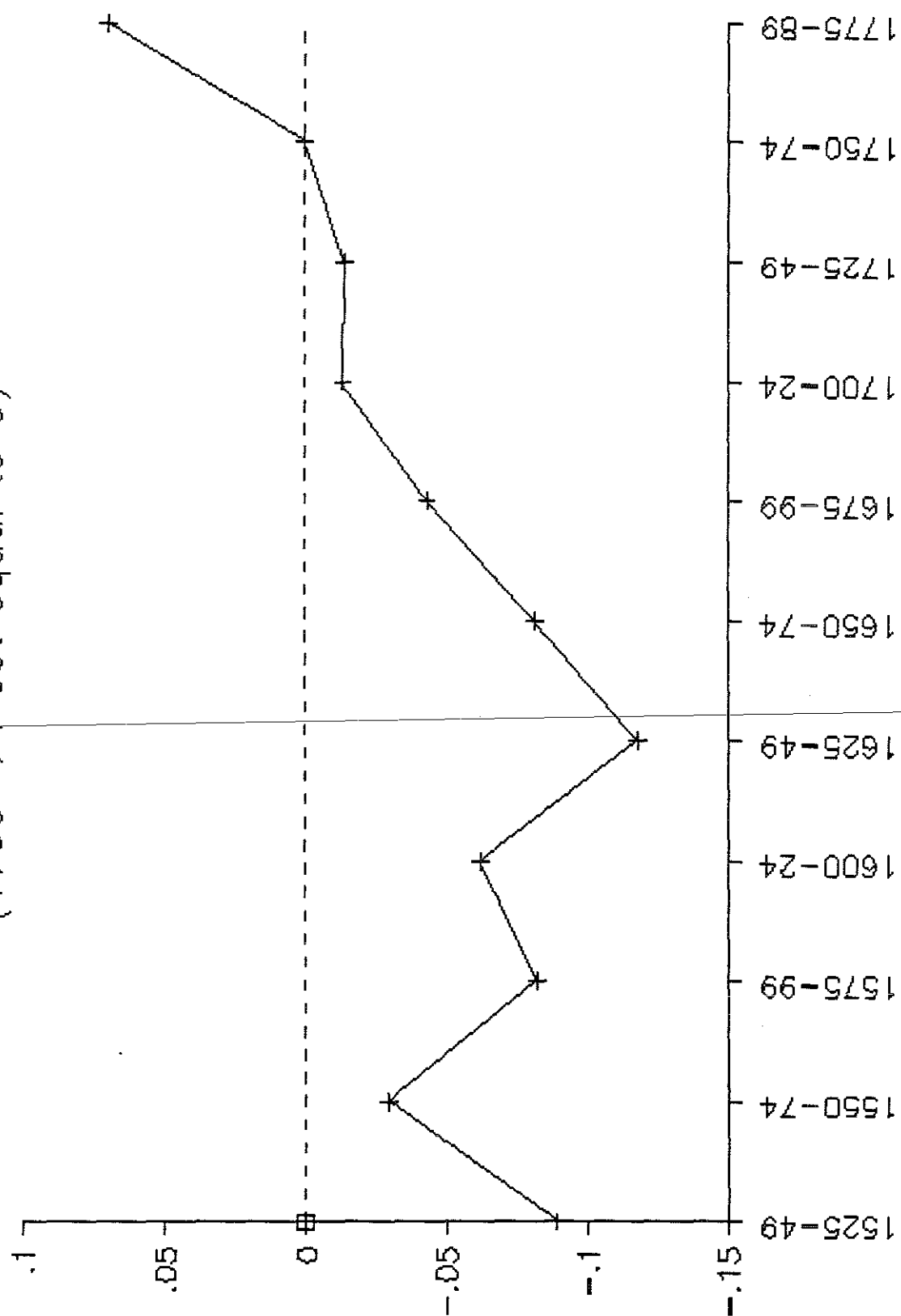


Figure 3: Rate of change of TFP  
(calculated from lease to lease)

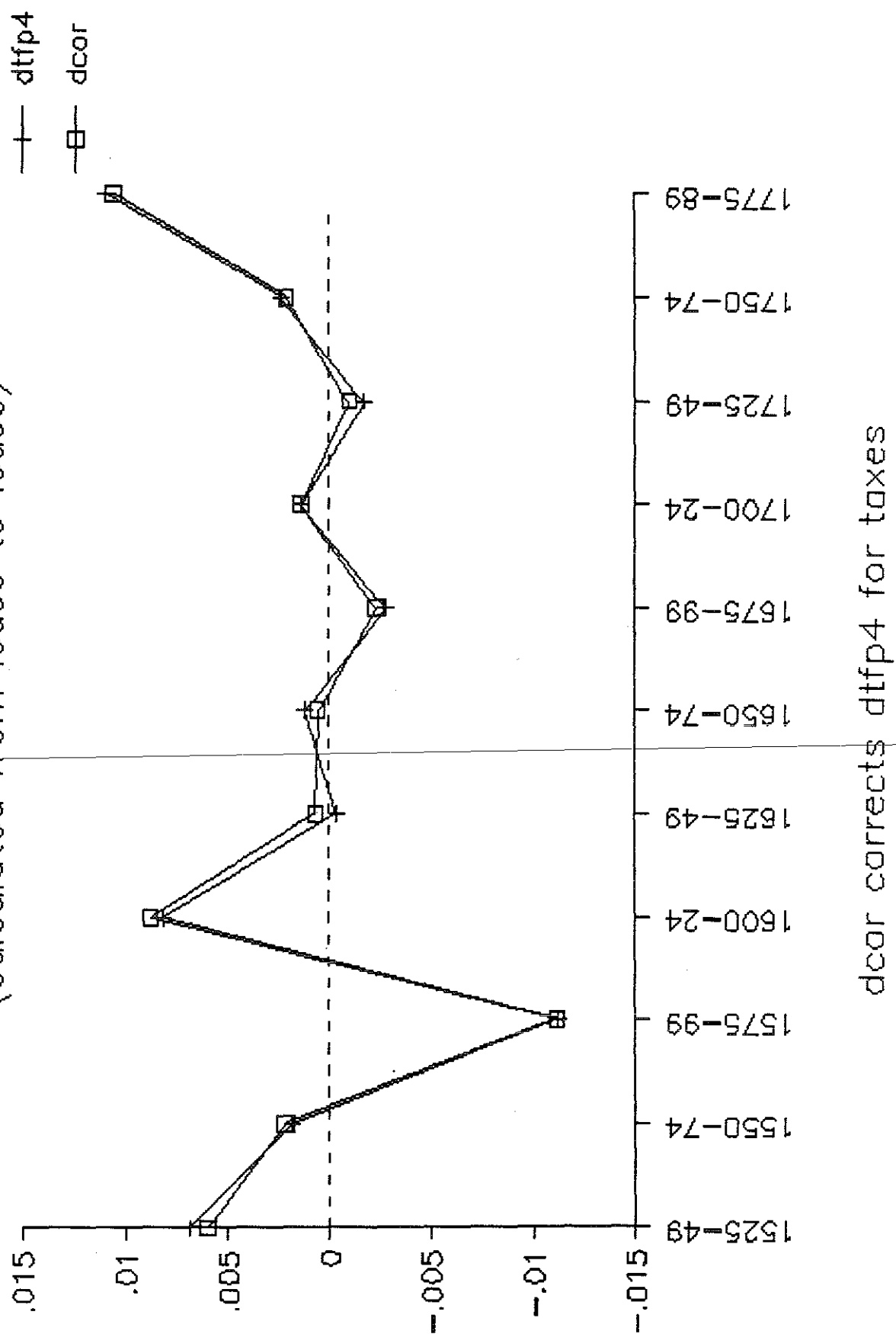
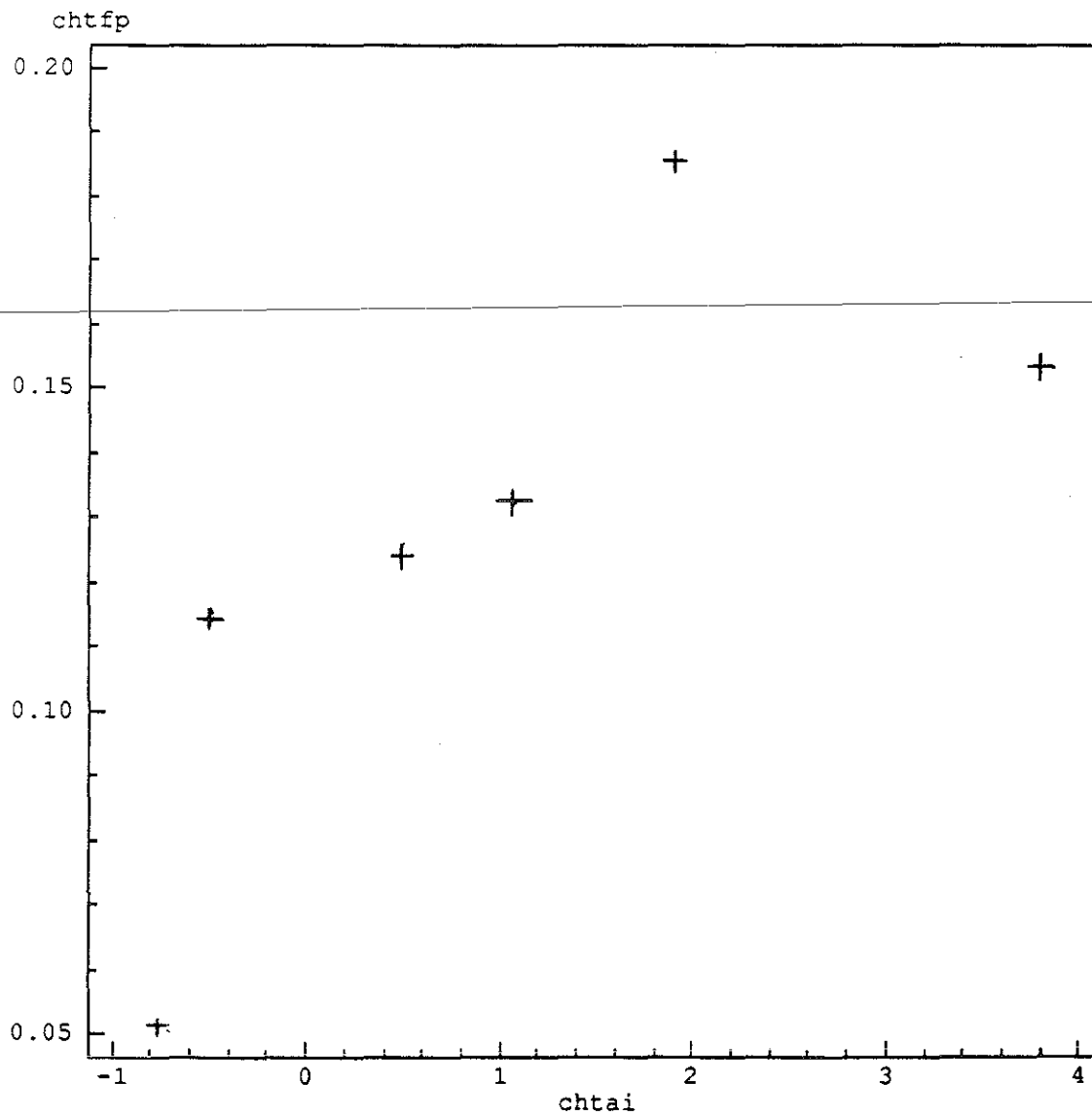




FIGURE 4:

CHANGE OF THE LOGARITHM OF TFP (CHTFP) versus CHANGE OF THE LOGARITHM OF TAX ASSESSMENTS (CHTAI) FOR SIX PROPERTIES, 1741 to 1783-86.



**TABLE 1**  
**REGRESSIONS WITH RENT AND TFP LEVELS**  
**(T-STATISTICS IN PARENTHESIS)**

Regression Numbers Dependent Variable	1 LNTPF	2 LNRENT	3 LNTPF
<u>INDEPENDENT VARIABLES</u>			
CONS	0.64 (3.77)	2.69 (3.77)	0.67 (4.10)
DM1775	$8.39 \times 10^{-2}$ (2.87)	0.35 (2.87)	$7.74 \times 10^{-2}$ (2.79)
DMWAR	-0.22 (-6.78)	-0.91 (-6.78)	-0.21 (-6.99)
PRE	0.14 (3.32)	0.61 (3.32)	0.10 (2.61)
VIGNE	$6.00 \times 10^{-3}$ (0.06)	$2.54 \times 10^{-2}$ (0.06)	0.12 (1.36)
GOODSOIL	$2.44 \times 10^{-3}$ (0.19)	$1.03 \times 10^{-2}$ (0.19)	$5.42 \times 10^{-3}$ (0.41)
LNPAR	$-5.91 \times 10^{-2}$ (-5.83)	-0.25 (-5.83)	$-6.13 \times 10^{-2}$ (-5.63)
HOLDOVER	$1.85 \times 10^{-2}$ (1.54)	$7.81 \times 10^{-2}$ (1.54)	$2.30 \times 10^{-2}$ (1.99)
YEAR	$2.34 \times 10^{-4}$ (2.36)	$9.88 \times 10^{-4}$ (2.36)	$2.44 \times 10^{-2}$ (2.52)
LNAREA	$-2.15 \times 10^{-2}$ (-3.67)	$-9.09 \times 10^{-2}$ (-3.67)	$-4.38 \times 10^{-2}$ (7.26)
LNARPC	--	--	$3.70 \times 10^{-2}$ (6.58)
OBSERVATIONS	638	638	581
R <sup>2</sup>	0.25	0.25	0.31
STANDARD ERROR	0.15	0.63	0.14
MEAN OF DEPENDENT VARIABLE	0.76	3.21	0.77
CONDITION NUMBER OF SINGLE VALUE DECOMPOSITION	93.5	93.5	98.5

NOTE: For the meaning of the variables, see the Glossary. Since LNRENT is just a multiple of LNTP2, the coefficients in regression 2 are multiples of those in regression 1. Years before 1520 have been omitted.

**TABLE 2**  
**REGRESSIONS WITH THE RATE OF CHANGE OF TFP**

(T-Statistics in Parenthesis)

REGRESSION NUMBER	1	2
DEPENDENT VARIABLE	DTFP	DTFP
<u>INDEPENDENT VARIABLES</u>		
CONS	$4.36 \times 10^{-3}$ (1.40)	$4.43 \times 10^{-3}$ (1.21)
DTRAT	$-3.77 \times 10^{-2}$ (-2.07)	$-3.97 \times 10^{-2}$ (-2.11)
DPARPOP	0.17 (4.96)	0.16 (4.71)
DM1775	$1.01 \times 10^{-2}$ (3.80)	$1.01 \times 10^{-2}$ (3.67)
DMWAR	$-2.20 \times 10^{-2}$ (-5.96)	$-2.06 \times 10^{-2}$ (-5.34)
REP	$-1.69 \times 10^{-3}$ (-0.53)	$-3.44 \times 10^{-3}$ (-0.96)
HOLDOVER	$-1.01 \times 10^{-3}$ (-0.85)	$-6.13 \times 10^{-4}$ (-0.49)
LNPAR	$-5.07 \times 10^{-4}$ (-0.54)	$-6.69 \times 10^{-4}$ (-0.63)
LNAREA	$-3.36 \times 10^{-4}$ (-0.69)	$-2.02 \times 10^{-4}$ (-0.35)
LNARPC	--	$-2.78 \times 10^{-4}$ (-0.47)
NUMBER OF OBSERVATIONS	648	593
R <sup>2</sup>	0.18	0.17
STANDARD ERROR	$1.49 \times 10^{-2}$	$1.49 \times 10^{-2}$
MEAN OF DEPENDENT VARIABLE	$1.15 \times 10^{-3}$	$1.15 \times 10^{-3}$
CONDITION NUMBER	14.3	16.6

Note: Years before 1520 have been omitted.

## GLOSSARY

### Explanation of Regression Variables

In all the regressions an observation consists of one lease for a single property; all rates of change are calculated from lease to lease. For sources see the Appendix.

LNTFP - the logarithm of TFP for the lease

CONS - 1

DML1775 - 1 if the lease is dated 1775 or later; 0 otherwise

DMWAR - 1 if the lease is dated between 1589 and 1597 (the years of the worst warfare about Paris, plus the following 3-year crop cycle); 0 otherwise

PRE - percent of the property in meadow

VIGNE - percent in vineyards

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GOODSOIL - 1 if the local soil is good

LNPAR - logarithm of the distance from the property to Paris in kilometers

HOLDOVER - 1 if one of the tenants is a holdover from the previous lease; 0 otherwise

YEAR - the year

LNAREA - the logarithm of the property area in hectares

LNARPC -  $\log \left( \frac{a}{n} \right)$  where  $a$  is the property area in hectares and  $n$  the number of separate plots of land making up the property; LNARPC is thus a measure of consolidation, though not a perfect one since two distinct plots might be adjacent.

LNRENT - logarithm of rent corrected for changes in the prices of agricultural

products and of the factors of production other than land; it turns out to be a constant times LNTFP.

DTFPL -  $\left(\frac{d}{dt}\right)$  LNTPF, i.e., the logarithmic rate of change of TFP

DTRAT -  $\left(\frac{d}{dt}\right) \log\left(\frac{\bar{t}}{\bar{r}}\right)$  where  $\bar{t}$  is an index of per-capita taxation and  $\bar{r}$  is a decade average of rent per acre across all properties. DTRAT allows us to correct the TFP figures for taxes; for details see the Appendix

DPARPOP - the time derivative of the logarithm of the population of Paris

REP - 1 if major repairs necessary to buildings on property; 0 otherwise

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